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SOVIET SPACE PROGRAMS: 1976–80

SUPPORTING VEHICLES AND LAUNCH VEHICLES, POLITICAL GOALS AND PURPOSES, INTERNATIONAL COOPERATION IN SPACE, ADMINISTRATION, RESOURCE BURDEN, FUTURE OUTLOOK

Prepared at the Request of

Hon. Bob Packwood, *Chairman*

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

Part 1

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LETTER OF TRANSMITTAL

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, D.C., December 3, 1982.

DEAR COLLEAGUE: I am pleased to transmit herewith for your information and use, a comprehensive report on the Soviet space program.

This report updates previous reports on Soviet launch vehicles, political goals and purposes, international cooperation in space, administration, resource burden and the future outlook.

It should prove to be a useful resource document on important matters over which this Committee has jurisdiction.

Cordially,

BOB PACKWOOD, *Chairman.*

LETTER OF SUBMITTAL

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, D.C.

Hon. BOB PACKWOOD,
Chairman, Committee on Commerce, Science, and Transportation, Washington, D.C.

DEAR MR. CHAIRMAN: Transmitted herewith is the first of a three part study, entitled Soviet Space Programs: 1976-80. Prepared at my request by the Congressional Research Service, the report presents a comprehensive and detailed overview of the Soviet space program.

This part contains detailed information on supporting vehicles and launch facilities, political goals and purposes, international cooperation in space, administration, resource burden, and the future outlook for Soviet space programs.

Part 2 of the study will review Soviet manned space activities and supporting life sciences research. Soviet unmanned space programs, including space sciences, applications, and military activities will be covered in Part 3.

Dr. Charles S. Sheldon II, one of the free world's foremost authorities on Soviet space activities died on September 11, 1981, during the preparation of this report. He worked as a senior specialist and chief of the Science Policy Research Division and the 1966-70 and 1971-75 editions of the Soviet space reports were prepared under his direction. His contribution as a public servant to our own space program through his knowledge will not be readily forgotten nor easily replaced.

In every respect this report is a remarkable accomplishment. It represents scholarship at the highest level. The CRS is to be congratulated for their commitment to the completion of this report. It will also stand as a tribute to Dr. Sheldon.

I believe this study of Soviet space programs resulted in an important report and will be most useful to the Committee and to other Members of the Congress.

Sincerely,

HARRISON SCHMITT,
Chairman, Subcommittee on Science, Technology, and Space.

Congressional Research Service,
The Library of Congress,
Washington, D.C., July 14, 1982.

Hon. Harrison Schmitt,
Chairman, Subcommittee on Science, Technology, and Space, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, D.C.

Dear Mr. Chairman: Pursuant to a formal request by your subcommittee in April 1979, which was reconfirmed by the General Counsel of the Committee in May 1981, the Congressional Research Service has completed the first part of a three-part review of Soviet space programs for the period 1976–80. The data in the attached report is current as of December 31, 1980.

All of the CRS and other individuals who contributed to this work have labored in dedication to the memory of Dr. Charles S. Sheldon II who died on September 11, 1981. Dr. Sheldon always will be remembered for his extensive and comprehensive contributions to the knowledge we have of the Soviet space program. During his work as a Senior Specialist and Chief of the Science Policy Research Division, Dr. Sheldon spearheaded the preparation of the 1966–70 and the 1971–75 editions of the Soviet space reports. At the time of his death, he was deeply involved in preparing this latest edition of the report. As articulated in the Journal of the British Interplanetary Society by Mr. Geoffrey Perry, a close friend and colleague of Dr. Sheldon, "he will be greatly missed, but his memory will live on—public servant, family man, friend, scholar, and a gentleman."

The attached part 1 of that review provides information on supporting vehicles and launch facilities; political goals and purposes; international cooperation in space; administration; the resource burden; and the future outlook for Soviet space programs. Subsequent parts, to be completed later in 1982, will review manned space activities and supporting life-sciences research (volume II) and unmanned space programs, including space science, applications, and military activities (part III).

The preparation of part 1 was coordinated by Mr. Christopher H. Dodge, Specialist in Life Sciences, and Ms. Marcia S. Smith, Specialist in Aerospace and Energy Systems of the Science Policy Research Division.

The following individuals contributed to part 1:

Mr. Geoffrey Perry, Senior Teacher at Kettering Boys' School, Kettering, England and the leader of the "Kettering Group" of satellite observers updated chapter 1, based on material prepared by the late Dr. Charles Sheldon II, Senior Specialist in Space and Transportation Technology, CRS, for the 1971–75 edition of this report. Dr. Sheldon had prepared most of the tabular data for chapter 1, as well as the Master Log of Soviet Space Flights that appears as appendix III in the present volume. Mr. Perry amended these tables as necessary.

Dr. Joseph G. Whelan, Senior Specialist in International Affairs, CRS, prepared the introduction, chapters 2 and 3, and contributed to the abstract.

Mr. Francis T. Miko, Specialist in Soviet Affairs in the Foreign Affairs and National Defense Division, CRS, prepared chapter 4.

Dr. John P. Hardt, Senior Specialist in Soviet Economics, CRS, and Dr. George D. Holliday, Specialist in International Trade and Finance, Economics Division, CRS, prepared chapter 5.

Contributions to the illustrations and tables contained in chapter 1 were provided on a voluntary basis by Mr. Charles P. Vick and Mr. David Woods, both private citizens with interest in Soviet space programs.

Mrs. Margaret Jean Sheldon, wife of the late Dr. Charles S. Sheldon II and Mr. Jeffrey Erickson, CRS student intern from the George Washington University Graduate School of Arts and Sciences, prepared the Chronology of Soviet Forecasts, which appears as appendix I.

Finally, Mr. Terrence L. Lisbeth, Ms. Stephanie E. Briscoe, Ms. Kaseem C. Hall, and Ms. Christine Anderson, under the direction of Ms. Shirley S. Williams, Production Support Unit of the Science Policy Research Division, CRS, provided editorial assistance in the preparation of the final manuscript.

The entire study has been peer reviewed by appropriate individuals although the final responsibility for accuracy rests with the authors and the Congressional Research Service. Thanks are especially extended to Mr. Sven Grahn, of Sweden, for peer-reviewing chapter 1.

It is hoped that these reviews will be of value to your subcommittee in evaluating Soviet space activities and we appreciate the opportunity to continue to serve your subcommittee.

Sincerely,

GILBERT GUDE, *Director.*

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Abstract

OVERVIEW, SUPPORTING FACILITIES AND LAUNCH VEHICLES OF THE SOVIET SPACE PROGRAM

Overall Trends in Flights

Statistics on space activities are only approximate and are subject to revision, but enough data are available to afford a reasonably good overview of rates of relative progress among nations.

Although the U.S. launch pace declined still further from 1976, the Soviet record shows no similar drop, peaking at 99 in 1976 and now running at about seven times the current U.S. level. While the U.S. record of success and failure in flight is fairly well known, the Soviet Union continues to hide most of its failures, and these can only be estimated as probably proportional to the number of successes in the same ratio as applies to the U.S. space record.

Despite the Soviet and American secrecy in hiding the missions of military space flights which overall make up a majority of launches, in both cases it is possible from open sources to deduce these missions. The largest single component in the Soviet program is still those flights which have a recoverable payload from low Earth orbit, presumably flown for observation purposes whereas, with the introduction of longer lived satellites with direct transmission of imagery from orbit, civilian communications satellites provide the largest single component for the United States. Examination of 25 program elements shows that both the U.S. and Soviet programs are broadly based, seeking multiple goals, with the primary difference being the Soviet inclusion of satellite inspector/destructor flights (ASATs). These flights were reintroduced in 1976 and have no U.S. counterparts.

In the absence of published data, only estimates can be made of the comparative weights of payload, and the launch capacity of the rockets used have been normalized to nominal low Earth orbit equivalents. These show the Soviet Union cumulatively has launched about 90 percent more tonnage than the United States, and is currently running about ninefold the U.S. level. The inauguration of the operational phase of the Space Shuttle should go some way toward redressing the disparity.

Launch Sites in the Soviet Union

With respect to Soviet launch sites, Tyuratam, located in Kazakhstan, is the Cape Canaveral of the Soviet Union, launching many research and development (R&D) flights, some observation flights, all manned, lunar, and planetary flights. It is officially called the Baykonur Kosmodrome, but it is 370 kilometers southwest of Baykonur, adjacent to the new rocket city of Leninsk. Landsat imagery reveals that the facilities are still being expanded.

Plesetsk is the Vandenberg Air Force Base of the Soviet Union, located north of Moscow toward Arkhangelsk. It is used mostly for military operational flights, most civil applications flights, and for extreme latitude scientific flights. Although it has made more launches than any other launch site it has never been named or pinpointed by the Russians.

The Kapustin Yar site on the Volga River near the Caspian Sea is equivalent to White Sands, N. Mex. and Wallops Island, Va. It is used to launch probes and one or two small satellites annually for civilian and military purposes, as well as conducting missile tests. The Russians now identify it as the Volgograd Station.

SOVIET LAUNCH VEHICLES

The standard launch vehicle series ("A"), an adaptation of the 1957 SS-6 Sapwood ICBM, (intercontinental ballistic missile), is still the mainstay of the Soviet program, with a first stage thrust of about 500 metric tons. It was used for Sputnik I and still is used for the Soyuz and many other flights today. It has been used more times than any other orbital launch vehicle in the world. With improved upper stages it will put up to 7.5 metric tons of payload in orbit. It is launched at Tyuratam and Plesetsk.

The small utility launch vehicle ("B"), an adaptation of the SS-4 Sandal MRBM (medium range ballistic missile), was used for the smallest direct-injection Kosmos flights problably with payloads ranging up to about 400 kilograms. It was first launched to orbit from Kapustin Yar in 1962 and later from Plesetek. It was last used in June 1977.

The flexible intermediate vehicle ("C"), an adaptation of the SS-5 Skean IRBM (intermediate range ballistic missile), may be able to put as much as one metric ton into low orbit. With a restartable upper stage, it is able to put payloads into circular orbits at various altitudes at least up to 1,500 kilometers. Introduced at Tyuratam in 1964 it is now launched from Plesetsk and Kapustin Yar and has taken over the role of the B-vehicle.

The nonmilitary large launch vehicle ("D"), first used for the Proton scientific payloads, is now used for deep space flights to the Moon and planets, for 24-hour synchronous flights, and for Salyut space stations. It can put about 20 metric tons into Earth orbit, or send up to about 5 metric tons toward a near planet at a favorable window. It is launched from Tyuratam, beginning in 1965, but has yet to be used for a manned spacecraft launch.

The military space launch vehicle ("F"), adaptation of the SS-9 Scarp, is used from Tyuratam to put up ocean surveillance radar flights, and earlier was used to loft both FOBS (fractional orbit bombardment system) and inspector/destructor flights. Flights to orbit began in 1966 and it has recently begun to be used to launch scientific payloads and some military payloads formerly orbited by the A-vehicle.

Presumably the very heavy launch vehicle ("G") was first launched in 1969, but through 1980 it had not made a successful flight. It may be designed to put about 135 or more metric tons into

Earth orbit, or to send over 60 metric tons toward the Moon after Earth orbit rendezvous with other elements. Estimates of first stage thrust range as high as 6,300 metric tons.

TRACKING AND OTHER GROUND SUPPORT

Tracking and communications with spacecraft are necessary to their successful use. The early Soviet support in this regard was limited and has had to be improved.

Soviet tracking facilities have been identified in part in connection with the Apollo-Soyuz test project, and some very elaborate missile and space defense tracking systems are also known to exist. The vast geographic extent of the U.S.S.R. provides a fairly adequate setting for such work.

There is a scattering of relatively modest tracking stations in countries party to the Interkosmos agreement, some Third World countries, and probably at Kerguelen and in Antarctica, but nothing corresponding to the big stations used by the United States at some overseas locations.

In the absence of good land-based overseas tracking stations, the Russians have put into service some fairly impressive large tracking ships both for Earth orbit support and for deep space mission support.

While deep space operations are aided by tracking ships, and there may be facilities in the Far East, the main deep space station is at Yevpatoriya in the Crimea, also the main flight operations center for Earth orbital flight.

Space operations and data processing centers were relatively simple at first, but over the years, better computer support and graphic displays have been introduced at the launch sites, at Yevpatoriya, and now at another manned operations center at Kaliningrad near Moscow.

Limited information is available about such space research centers. Two well-known ones are the Leningrad Gas Dynamics Laboratory and the Moscow Space Research Institute.

With respect to manufacturing and assembly centers for spacecraft and rockets, probably much construction is carried out in conjunction with aircraft plants, with use of rail transport to deliver modules to the assembly buildings at the launch sites for further testing.

In the matter of test and training centers for space, environmental chambers and other test equipment are used increasingly, often with the actual flight matched on Earth by an analog exposed to as close to the same environment as can be achieved. The principal training center for manned flight is at Zvezdnyy Gorodok in the Moscow suburbs.

POLITICAL GOALS AND PURPOSES OF THE U.S.S.R. IN SPACE

INTERNATIONAL SETTING

The Soviets pursued their political goals and purposes in space during 1976–80 within a familiar but rapidly changing international order. Multipolarity had long supplanted the bipolar world that had been shaped by Soviet and American rivalry during the cold war. The superpowers still command center stage in world affairs; but the constraints and limitations on the use of that power, along with other factors, have diminished the political effect of their enormous strength. International terrorism introduced a new and perplexing element on the international scene. The diffusion of power within competing East-West blocs continued to erode political control from the center. The effects have been to further weaken the power and authority of the superpowers as the principal actors in world affairs. The spirit of nationalism continued its forward surge in the Third World turning loose forces that have created in the Third World a formidable international power base; no longer can the great powers assure the manageability of the Third World. Interdependence, a countertrend, also became a stronger element in world affairs, diverting much attention away from East-West problems and redirecting it toward those between North and South. Science and technology continued to play a prominent role as creators of international problems and as vital components in their solutions through diplomacy. Finally, the rise of the Islamic movement added still another new, and unpredictable, element in an already complex international order.

Distrust and fear lay at the roots of the Soviet-American relationship. Perhaps more than any other element these characteristics have been responsible for producing the discord that has plagued their relations for some 63 years. Equally formidable as an obstacle to harmony is the conflict in ideologies and political perspectives. This conflict is most discernible in differing views on political change in the world and on such vital matters as human rights. The depth of these differences when combined with distrust and fear creates a formidable obstacle to good relations. The Soviet invasion of Afghanistan was to deepen these differences and broaden the void of misunderstanding, for here was a dramatic portrayal of these essentially abstract elements in conflict being acted out in a practical, real world setting.

SOVIET POLITICAL USES OF SPACE

Past studies in this series on Soviet space activities revealed that space exploration, though strictly a scientific and technological undertaking, has important political uses, and that the Soviet Union, valuing space as an instrument of politics, has over the years seemed to have taken every opportunity to exploit space for political purposes and for the advantages accruable in foreign policy. Among some of the familiar themes was the downgrading of American space efforts that was generally juxtaposed in Soviet propaganda with efforts to magnify and often distort Soviet space achievements. The underlying purpose was to maintain and increase the prestige of the Soviet Union, meaning a reputation for power. Within this pattern efforts were persistently made to identify Soviet space achievements with the Soviet Communist Party and the Soviet Government, emphasizing that both were the source of Soviet success. The sum and substance of Soviet political uses of space was to glorify the Soviet Union, its institution, people, leaders, and ideology, and emphasize the value of space exploration as a worthy enterprise.

EMERGING TRENDS

Taking a retrospective view of Soviet space politics during 1976-80, three overarching trends appear to be discernible: (1) a growing complexity in the international environment that reduces the ability of the superpowers to exercise their control over international events; (2) a decline in detente that presages the possibility of cold war II; and (3) an emerging maturity in the Soviet management of space politics, except in military related space activities.

Emerging radical and destabilizing forces, especially in the Third World, add to existing complexities and risks in world affairs. These conditions make it increasingly difficult for the superpowers, if they so wish, to establish mutually acceptable "rules of the game" upon which a reasonable and stable relationship can be based. Deterioration of detente further complicates international politics and lowers the threshold of risk. The effects could be to slow down, and perhaps prevent, further improvement in space relations since space politics, particularly international space cooperation, are determined by East-West political relations. Under Khrushchev space became a weapon of the cold war. Under Brezhnev in the early 1970's it became an instrument of detente. What it will be in the 1980's remains an open question.

SOVIET ATTITUDE TOWARD INTERNATIONAL COOPERATION IN SPACE

SPACE COOPERATION

Space cooperation has become imperative in the present era. Once the sole concern of the superpowers, space now commands varying degrees of attention of virtually all nations in what has become an ever expanding universe of space activity. The pacesetters of space exploration, the United States and the Soviet Union, have now been joined by such newcomers as France, Britain, West Germany, and other members of the European Space Agency (ESA), Russia's allies in the Interkosmos program (including Eastern Europe), China, Japan, and India. And with the application of space systems to such variegated enterprises as communications, meteorology, the study of Earth resources, and oceanography, there is perhaps no nation in the world today that is not in some way affected by some aspect of space science and space exploration.

This expanding universe of space activity creates conditions that foster cooperation, and the two major space powers, realizing its political, economic, and scientific value, have long shared a common commitment to international space cooperation. Both have developed extensive international arrangements for cooperation, though the range of Soviet cooperation is overall rather limited in scope involving relatively few countries in comparison with the U.S. cooperative programs. Both are committed to the continuation of such arrangements, for the reality of an expanding universe of space activity imposes upon them the necessity of cooperation. But there is a difference: Fewer programs in the Soviet space effort are cooperative in nature, at least in the same sense as those carried on in the West.

SOVIET-AMERICAN BILATERAL SPACE COOPERATION

In reviewing the period 1976–80, certain trends were discernible in Soviet-American space relations, and the most significant was the continued Soviet progress in space in contrast with an apparent lagging U.S. effort. Retrenchment in U.S. space activities after the conclusion of the Apollo program was a second major trend. Competition and cooperation in space was the third. And the final trend was the downturn in relations and its adverse effects on space cooperation brought on by an accumulation of political differences that culminated in the Soviet invasion of Afghanistan.

A review of Soviet-American space relations during 1976–80 suggests three generalizations; namely, the primacy of politics in determining the limits of cooperation; the prevailing sense of realism wherein advantages of cooperation are not foreclosed; and the demonstrated willingness of the Soviets to cooperate in some areas.

In Soviet-American space relations cooperation is sometimes a necessity; in space relations within the Soviet bloc it is probably always a necessity. The Soviets place a high value on space cooperation with their allies because it has become an integrating force for unity within the Soviet bloc. Science and technology have made progress in Eastern Europe, creating the basis for at least some forms of participation in space exploration. Accordingly, these countries participated in programs that served their interests as well as those of the Soviets.

OTHER AREAS OF SPACE COOPERATION

Organizational arrangements for space cooperation between the Soviet Union, Eastern Europe, and other Communist states (excluding China) were created within two institutions, Interkosmos and Intersputnik. The primary function of Interkosmos is to oversee and coordinate Soviet space cooperation with East Europe and other Communist countries. The Interkosmos program has covered a broad range of space-related scientific problems in physics, meteorology, communications, biology and medicine, and in the study of the environment. The primary purpose of Intersputnik is to provide an international system of space communications, using satellites in space and complexes on the ground. Bulgaria, Hungary, the GDR, Cuba, Mongolia, Poland, Rumania, Czechoslovakia, Vietnam, and the Soviet Union constitute the membership of both organizations. Political motives seem to underlay Soviet purposes in Interkosmos. For space cooperation encourages the forces of East European integration and provides an attractive instrumentality for achieving political gains in international politics, particularly in the Third World. The Soviets have also been able to draw upon the scientific and technical resources and skills of their allies. Soviet space cooperation was also extended to France, a space power in its own right. France carried on an extensive program of space cooperation not only with the United States but also with the Soviet Union. Established by President Charles de Gaulle in 1966, Soviet-

French space relations have expanded progressively, and impressively, under succeeding governments.

Expanding space relations with France opened up potential opportunities for the Soviets to influence the French politically, particularly in seeking the much cherished Soviet foreign policy goal of dividing the West. In the case of India, space cooperation played a similarly unique political role, that of an instrument for expanding Soviet political influence in this leading country of the Third World, and thus furthering its larger purpose of linking the Third World to the Soviet Union's expected, but doubtful, global destiny.

The Soviet Union was a major contributor to India's space effort. Foremost was Soviet technical assistance in building and in actually launching India's satellites, Aryabhata and Bhaskara. Other forms of cooperation, such as practical experiments in meteorology, were also undertaken. India has, moreover, accepted the Soviet invitation to nominate two candidates for cosmonaut training in preparation for a joint manned space flight in 1983.

Soviet bilateral cooperation with other non-Communist countries appears to have been minimal. Perhaps one reason for this has been their virtual self-sufficiency in tracking. In contrast, the United States has had to maintain a worldwide tracking system which requires negotiating arrangements with host countries. Whether Soviet space relations with other non-Communist countries will expand can only be a matter of speculation. The appeal of space cooperation, however, cannot be minimized, particularly for countries of the Third World who, like India, have valued the practical application of space technology to their development needs.

In no institution has the Soviet commitment to space cooperation been more consistently reflected than in the United Nations. The Soviets have been among the major actors in the United Nations, and as a leading space power they have played an important role in the work of the Committee on Peaceful Uses of Outer Space. On some issues, such as the Moon Treaty and direct satellite broadcasting, sharp differences have arisen; the adversarial spirit has not diminished appreciably; but achievements have been made in recent years (for example, the Convention on Registration of Objects Launched into Outer Space of 1976, among others) that probably never would have been contemplated early in the Space Age.

The Soviet Union carries on multilateral cooperation in space-related matters within other international organizations. Prominent among them are COSPAR, in International Telecommunications Union (ITU), and the International Astronautical Federation (IAF). COSPAR and IAF congresses have proved to be clearing houses for the exchange of information and ideas on space. The Soviets have been active participants in both, though, in the case of the IAF, cooperation has not been entirely satisfying to some Western observers. But the principal problems facing the ITU, namely, the allocation, the radio frequency spectrum, and slots in geostationary orbit, compel Soviet participation as a matter of practical necessity because the spectrum is held in common and must be allocated by agreement to prevent interference. In the present era of expanding technologies in space communications and increasing pressures from the Third World for greater access to the spectrum, the ITU has become a central point of negotiations where cooperation will be imperative.

SPACE COOPERATION: SOME GENERALIZATIONS

Soviet space cooperation during 1976–80 suggests generalizations consistent with those recorded in the previous study: The Soviets are committed to and maintain a positive attitude toward space cooperation. The record of bilateral and multilateral cooperation, however uneven, supports this judgment.

Whether Soviet-American space relations will improve depends upon conditions at the political level. A reading of the international realities of 1980 and early 1981 and the apparent trend toward a diminishing U.S. commitment to space offer little encouragement for better times, at least in the short term.

However, space cooperation is a fixed principle in contemporary international life. In an interdependent world, selective cooperation is an indispensable political tool serving the interests of all. It has a future, whatever the state of Soviet-American relations, but a future whose full potentialities can only be realized in a climate of reasonable peace and harmony.

ADMINISTRATION OF THE SOVIET SPACE PROGRAM

INTRODUCTION

The open literature provides little definitive information on the administration of the Soviet space program. It is a subject not discussed in Soviet literature. Yet some broad generalizations can be made from the fragments of available evidence, combined with what is known about the general Soviet approach to high-priority programs.

LEADERSHIP INTEREST IN SPACE

The Communist Party exercises overall control from the top through its Central Committee and ruling Politburo and at every level through an elaborate network of "political secretariats." The top decisionmaker on space is the General Secretary of the party whose degree of personal involvement depends on his own interest and discretion. There are indications that Nikita Khrushchev, as a space enthusiast, involved himself intimately. Perhaps Leonid Brezhnev participates less directly. But the top Soviet leadership continues to demonstrate a firm commitment to the space program and, as a result, presumably takes an active role in decisionmaking on space. The Politburo member charged with directing the space program is thought to be Defense Minister Dmitriy F. Ustinov. He has been identified with that responsibility for a number of years. His appointment to the post of Defense Minister in 1976 while continuing in the role of top Soviet space official seems to affirm the close link between the defense establishment and the space program.

ROLE OF THE COMMUNIST PARTY AND GOVERNMENT

At the government level, the directives of the Communist Party leadership are received by the Council of Ministers. The coordination is simple because the council includes several of the party leaders. The Council of Ministers and state committees oversee many of the elements going into the space program. The most important are the Ministry of Defense, the Ministry of Defense Industries, the State Committee on Science and Technology, the State Committee on Planning the Military-Industrial Commission, and the Ministry of Instrument Making, Automation Equipment, and Control Systems. Among them, they control the industries and the research and development involved in the space program.

DOMINANT ROLE OF THE MILITARY ESTABLISHMENT

The military establishment plays a large, possibly dominant, role in the space program. Military influence seems to be exercised both directly and through other institutions on which it is heavily represented. In this context, it seems revealing that most of the individuals who are identified as high officials in the space organization have strong military or defense industry backgrounds. The military participates directly in the space program at another level. The Air Force is responsible for cosmonaut training and vehicle recovery. The Strategic Rocket Force conducts all space launches. The three major launch sites are administered by the military.

ROLE OF THE SCIENTIFIC ESTABLISHMENT

The Soviet Academy of Sciences and its subsidiary organizations are extensively involved in the space program, but possibly not in the central role sometimes attributed to them. The academy and its members are held in the highest esteem in the Soviet Union, but there appears simultaneously to be an element of mistrust toward the scientific establishment and the academy within the party and state heirarchy. Furthermore, the academy does not seem to be set up in a manner that would allow it to be the most effective coordinator of the space effort.

CONCLUSIONS

In sum, there appears to be a central coordinating mechanism which lies outside the science academy and outside the military structure and which includes high-level representatives from the major participating groups; namely, the Communist Party, the military, the scientists, and the sectors of the Soviet economy involved in the space program. Whether this mechanism is a formal agency such as the much discussed "State Commission on Space" or just an informal grouping of key individuals remains an open question. There is strong opinion, but no conclusive evidence on either side. Regarding the membership of this coordinating body, speculation by various Western observers has been included as a point of interest. However, due to the tight veil of secrecy that surrounds key Soviet space figures, their identification remains a highly conjectural exercise.

RESOURCE BURDEN OF THE SOVIET SPACE PROGRAM

INTRODUCTION

The Soviet space program has reflected national economic, political, and military goals more clearly than the U.S. program. The correlation of Soviet national objectives in military and civilian space has been facilitated by the apparent centralization of decisionmaking in the Politburo of the Communist Party and is less distinctly separated than in the United States.

As the military claims on investment funds began to be assessed more critically in the late 1960's, the space claims may have come under increasing scrutiny. There appears to be an increasing awareness of the potential alternative use of scarce resources now allocated to the space program. The sophisticated demands of civilian investment programs (for projects such as petrochemical plants) appear to have been given increasing attention. In considering these competing demands for resources, the part of the space budget that did not contribute directly to military strategic systems was probably under the most severe pressure.

SOVIET SECRECY

Soviet space allocations and space activities fit largely under the coverage of the pervasive secrecy system. As a result, direct information on either space budgets or activities are difficult to obtain directly from Soviet sources. To be sure, an annual state budget is published with single line items for military and science. Space activities are included in those categories. But there is no reason for confidence in any consistent interpretation on the comprehension, reliability, or comparative meaning of these figures. U.S. intelligence estimates suggest that Soviet military and civilian space spending could be as much as 1 to 2 percent of Soviet gross national product.

SOVIET SPACE SPENDING

If correct, this estimate implies a space budget of $7 to $14 billion in 1974, and $14 to $28 billion in 1980—a level of expenditure that is considerably larger than the present U.S. program and probably approximates (for 1974 in real terms) the U.S. space effort at its peak in the 1960's. While the U.S. military space programs accounted for approximately 30 to 40 percent of total U.S. space spending during the 1970's, comparison of the ratios of military to civilian satellite launchings suggests that the Soviet Union devotes a much larger proportion of its space budget to military applications than the United States.

BURDEN AND OPPORTUNITY COSTS OF THE SOVIET SPACE PROGRAM

In estimating the economic burden of the Soviet space program, simple dollar estimates should be supplemented by assessments of opportunity costs. Unfortunately, we cannot determine Soviet perceptions of opportunity costs with great precision. However, our knowledge of Soviet "internal and bureaucratic and organizational politics" does provide a basis for determining whose perceptions of opportunity costs are most important. Moreover, various policy statements and official economic plans give some insights, if not hard evidence, of what priorities are attached to competing economic goals.

The dominant role is clearly played by the Politburo of the party's Central Committee and particularly by the General Secretary, Leonid Brezhnev. However, given the size and complexity of the Soviet scientific research effort in these areas, party leaders undoubtedly rely heavily on scientists for advice on funding priorities. The rising space budget is evidence that scientists who support the space effort have been influential on the party leadership.

FUTURE PROSPECTS

Soviet leaders have shown an increasing concern about the progress in civilian industries, transportation and agriculture. Yet, even with a significant increase in the civilian share of investment funds, it will be difficult to meet the pressing needs of those sectors of the economy. Thus, it would seem clear that the opportunity costs of diverting resources to military and space programs should be very high for Soviet decisionmakers. However, if military and space superiority is deemed to be an attainable and desirable goal or if defensive needs are overriding, the cost may be bearable. It should be emphasized that the specialized, high-technology inputs of the Soviet space program are not easily convertible to civilian investment needs in the short run. Nevertheless, the difficult economic choices which confront Soviet leaders in the 1980's are likely to force them to reconsider all existing resource allocation patterns including the continued priority to space.

Introduction

The Continuing Soviet Commitment to Space *

BACKGROUND

This introduction, based on the material contained in this volume, attempts to project the future outlook of the Soviet space program in a synthesized form. It should be understood by the reader that such a projection carries with it a certain element of risk, because the Soviets rarely announce their plans in advance. Nonetheless, an attempt is made here to identify trends for the possible future directions of the Soviet Union in space.

SPACE INFRASTRUCTURE IN PLACE AND WORKING

It is important to note, first of all, that an imposing infrastructure for space exploration is in place with long established launch sites; launch vehicles of proven ability; tracking and ground support on Soviet territory, aboard Soviet ships at sea, and at stations in the Interkosmos countries and the Third World; and centers for space research, processing data, testing and training.

And this space infrastructure is busily at work particularly in militarily related space activities where Soviet efforts predominate. The Soviet's launch pace, accelerating in contrast to the declining U.S. rate, now runs at about seven times the current U.S. level, having peaked at 99 in 1976. The launch tonnage capacity of Soviet rockets measured cumulatively is about 90 percent more than the United States and is currently running about ninefold the U.S. annual level.

Such data reinforces the judgment of Geoffrey Perry and Charles Sheldon that the Soviet space program "remains a strong, ongoing enterprise" and that it gives "every indication of a continuing commitment to maintain a high level of activity and investment in a long-term orderly development of space science and technology. . . ."

In brief, the Soviet space program is very much a continuing concern with a certain future.

AN INVITATION TO INTENSIFY SPACE POLITICS

The continuation of a firm commitment to space exploration and the maintenance of a high level of space activity are likely to intensify Soviet space politics, judging from past Soviet behavior. As

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* Prepared by Dr. Joseph G. Whelan, Senior Specialist in International Affairs, CRS.

past studies in this series demonstrate, the Soviets have always placed great value on space exploration as a political instrument for accruing prestige and influence in world politics. This practice was particularly evident early in the Space Age when Soviet space success could be compared more favorably against those of the United States. A surging Soviet space program pitted against an American program in retrenchment, particularly in an environment of deteriorating political relations, could create irresistible political opportunities for the Soviets to play space politics with even greater intensity.

It is clear on the basis of over two decades' experience, that so long as achievements in space can be viewed by world opinion as a valid measure of national greatness, power, and systemic virility, space politics will always have a life and a future.

INTERNATIONAL SPACE COOPERATION: MIXED POSSIBILITIES

The same conditions of a surging Soviet space program, retrenchment in the American program, and deteriorating Soviet-American political relations suggest the likelihood of a constriction rather than an expansion in future bilateral Soviet-American space relations. Space cooperation on the larger international scale could also be adversely affected, though not necessarily in specific areas of Soviet interest.

Necessity requires international cooperation in certain areas of space activity. Therefore, it seems likely that Soviet cooperation in space will continue at a satisfactory, perhaps even at an accelerated, pace with the countries of Interkosmos, those in the Third World like India, and France among the non-Communist space powers.

But the downturn in Soviet-American bilateral space relations after Afghanistan has yet to be reversed, and, judging from developments during 1980–81, they are not likely to be reversed for some time. Negotiations have begun on the control of intermediate range nuclear missiles in Europe. Negotiations on strategic weapons are expected to begin in the latter half of 1982. Nonetheless, these negotiations are expected to be long, difficult, and, perhaps for sometime, inconclusive.

Prospects for improvement in Soviet-American political relations at this writing appear to be dim. Prospects are, therefore, equally dim for bilateral space relations since they are but a reflection of the former.

THE POLITICAL LEADERSHIP: PATTERN OF CONSTANCY AND CONTINUITY IN SPACE COMMITMENT

Constancy and continuity have seemed to be persistent characteristics in the Soviet space commitment, in contrast to the United States whose commitment has in recent years and particularly of late been on the wane. These Soviet characteristics are likely to continue under Brezhnev's successor regime now waiting in the wings to assume power.

Khrushchev first committed the Soviet Union to space exploration; Brezhnev reaffirmed this commitment. Soviet involvement in space for over two decades has thus become a national commitment, an integral part of a national policy in which the prestige, position and judgment of the party and all its constituent parts have been placed on the line. And so long as political, economic, and particularly highly significant military benefits are to be derived from space activity, this commitment is more likely to deepen than to diminish.

ECONOMIC CONSTRAINTS ON PRIORITIES IN SPACE

But the future Soviet outlook in space will be determined largely by the allocation of economic resources that the present and immediate successor leadership will make in space exploration.

For the Soviet leaders, space exploration in dollar estimates and opportunity costs has been a burden that up to now they have been willing to bear. This cost in dollars has been estimated at some $14 to $28 billion in 1980, a figure far higher than the present U.S. program and one that probably approximates the U.S. space effort at its peak in the 1960's.

Nevertheless, the Soviet leadership faces difficult economic choices in the 1980's as the Soviet Union enters a period of economic stress.[1] These choices are likely, therefore, to force them to reconsider all existing patterns of resource allocation, including the continued priority given to space.

A SUMMING UP

To sum up, the Soviets have a continuing commitment to space. They have the infrastructure, the material resources in space systems, science and technology, along with the will to maintain their space activity at a high level.

Space politics and certain areas of international cooperation in space offer attractive incentives, some by necessity, for a system whose world outlook encourages the search for political gains and an expansion of its ideology. For this reason, along with the real and potential yield from the military application of space, the Soviets have maintained a constancy and continuity in their space commitment.

But ironically, as creatures of economic determinism, their goals, expectations and future activity in space will be determined in the 1980's by the price in resources they are willing to pay, and that price must be calculated within the context of other pressing and competing priorities in the contest for resource allocation.

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[1] For a discussion of this problem, see, The 26th Soviet Communist Party Congress. Washington, The Library of Congress, Congressional Research Service, Sept. 1, 1981, pp. 39-63. (Report No. 81-203.)

Chapter 1

Overview, Supporting Facilities and Launch Vehicles of the Soviet Space Program *

OVERALL TRENDS IN FLIGHTS

The purpose of this section is to provide a perspective on the trends of development of the Soviet space program, including data on its general composition before turning in detail to particular components. To this end, statistical tables were developed by the late Charles S. Sheldon II which covered the entire period of flight operations even beyond the years on which this report is concentrated. It may be noted by the discerning reader of earlier publications in this series, that over a period of time some numbers in historical tables are modified from those previously published. This is because even at this late date, there are some new disclosures and also fresh interpretations of old data based upon more recent events which permit a refinement and more meaningful interpretation of what was even less perfectly understood earlier. In one sense, there never will be final figures for many tables. Not only do governments maintain policies of secrecy, but many numbers are based upon arbitrary definitions which are only occasionally spelled out in sufficient detail to be able to understand why two tables which purport to cover the same events come up with different numbers.

For the most part, Soviet official numbers show fewer variations than do their U.S. counterparts. This may be because when an early estimate is made and published, the Soviet authorities continue to use those data, even if their own computers later could make available slightly different refined figures.

While this study does not present a complete comparison of Soviet space data with that of other nations because it was not called for in our terms of reference, some of the tables which follow do include worldwide coverage in order to provide a perspective on the Soviet effort.

The basic data come from national announcements such as Tass bulletins and National Aeronautics and Space Administration (NASA) press releases, plus the compilations of several national agencies. Most of the basic worldwide record maintained by the United States is compiled by North American Aerospace Defense

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* Prepared by the late Charles S. Sheldon II and Geoffrey E. Perry M.B.E. Dr. Sheldon was the Senior Specialist in Space and Transportation Technology, Mr. Perry is a Senior Teacher at Kettering Boys School, England, and the leader of the Kettering Group of amateur satellite observers.

Command (Norad), a joint U.S.-Canadian activity at Colorado Springs. Norad data are passed to the Goddard Space Flight Center which selects a part of these data and may add a few items of NASA origin which are then issued every other month. There is a corresponding activity in the United Kingdom. The Space Department of the Royal Aircraft Establishment at Farnborough, Hants, has an orbital analysis group headed by Desmond G. King-Hele which once a month issues a limited circulation tabulation combining data from many sources to provide more data than the basic U.S public lists show. These preliminary monthly lists are cumulated and corrected from time to time and a hardback edition of the first three volumes, covering the years 1959 through 1980, has recently been published.[1] In addition to the above official sources, an unofficial list with additional details compiled by Robert D. Christy for the British Interplanetary Society is carried monthly by Spaceflight in London.

GROSS STATISTICS

Tables 1 and 2 are world summaries by years of launches and payloads to Earth orbit or beyond, successes and failures to the extent known or estimatable for each country. As such, they reveal something about trends, but nothing about the size, the effectiveness, or the utility and significance of each flight. According to the tables, the Soviet Union reached a peak in a number of successful launches in 1976. This contrasts with the U.S. peak of 1966 from which declines have brought this country down by about 82 percent. the flights of all other nations are minor by comparison with the two space leaders.

The record on payloads to Earth orbit, given in tables 3 and 4, is somewhat more erratic because the count includes a scattering of flights in which a considerable number of payloads were sent up together. Even so, approximately the same trends are reflected as for launches. For the so-called escape payloads, those sent to the vicinity of the Moon, the planets, or around the Sun, listed in table 5, the number of payloads is much smaller. Table 6 combines data from the first five tables, independent of consideration of the launch agency.

One can be reasonably sure that the record of successful launches is complete. The number of payloads may be nearly right, although there is always a chance of a pickaback which for some reason was not announced, or a piece of debris was thought to be a useful payload in the absence of information to the contrary. On the other hand, the record of failures is very problemmatical overall. The U.S. count on launch failures is probably accurate despite the reluctance of our Government to give prominence to these failures. The number of U.S. payloads lost through failure to reach orbit is more suspect because there is no legal obligation to report how many payloads a launch vehicle may have contained. The counts for all other non-Communist nations and their international agencies are probably accurate. There is no reliable public record of possible Soviet or Chinese launch failures. Only two Soviet launch failures have been acknowledged by that nation. (These were the Soyuz launch of April 5, 1975, and a launch on June 3, 1975, which included a Swedish experiment.) In addition two Soviet launch failures were officially publicized by the U.S. Government. (These were the Mars attempts of October 10 and October 14, 1960.) However, because of the Soviet use of the orbital launch platform technique for sending payloads either to deep space or to eccentric Earth orbit, a strong inferential case based upon time of launch and behavior of debris can be made that 22 payloads intended for escape missions fell short of that objective, and count as "failure" even though they were in most cases Earth orbital "successes." In some of these cases, the Soviet Government did not acknowledge the fact of launch. For the purposes of these tables, judgments on success or failure of launches and payloads are based exclusively on whether hardware attained Earth orbit or "escape," not on whether the payloads functioned and returned data. There is no public basis for classifying by operational effectiveness the payloads of most of the Soviet flights and those of the U.S. Department of Defense.

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[1] King-Hele, D. G., J. A. Pilkington, H. Hiller & D.M.C. Walker, The R.A.E Table of Earth Satellites, 1957-80, Macmillan, London, 1981.

There were two choices open to the analyst in estimating the unreported and unmeasurable Soviet or Chinese failures. One was to compile a list of rumors (as has been done by J. A. Pilkington in the United Kingdom); the other was to argue that development of a common technology has probably moved at a somewhat similar pace in different countries, and therefore the known failure rate of the United States could afford order of magnitude ratios to apply to the records of those countries which do not admit to failure. The latter course has been followed. Neither the rumor approach nor the common ratio approach can be counted upon to be accurate. What would not be satisfying would be to accept uncritically the oft-repeated early Soviet claim that their program, unlike the American, has no failures. In the 1970's the Russians issued a feature length motion picture, "The Taming of the Fire," which was a fictionalized account of the life of rocketeer Sergey Korolev, and this included footage of one spectacular near launch site failure after another, to reflect the problems of the days Korolev was developing the standard launch vehicle. The pictures appeared to be genuine, and in any case represented a shift in policy by acknowledging that all space programs have their difficulties. The directly measurable Soviet failure rate for their deep space program runs higher than a simple ratio comparison with the United States would suggest, but this may have something to do with their use of the orbital launch platform technique, and poorer worldwide support facilities for this phase of their flights.

TABLE 1.—WORLDWIDE RECORD OF KNOWN SPACE LAUNCHINGS—SUCCESSES

Year	United States	U.S.S.R.	Japan	France	China	Italy	European Space Agency	India	Australia	United Kingdom	World total
1957		2									2
1958	5	1									6
1959	10	3									13
1960	16	3									19
1961	29	6									35
1962	52	20									72
1963	38	17									55
1964	57	30									87
1965	63	48		1							112
1966	73	44		1							118
1967	57	66		2		1			1		127
1968	45	74									119
1969	40	70									110
1970	[1]28	81	1	2	1	[2]1					114
1971	[1]30	83	2	1	1	[2]2				1	120
1972	[1]30	74	1			[2]1					106
1973	23	86									109
1974	22	81	1			2					106
1975	[1]27	89	2	3	3	[2]1					125
1976	26	99	1		2						128
1977	24	98	2								124
1978	32	88	3		1						124
1979	16	87	2				1				106
1980	13	89	2					1			105
Total	756	1,339	17	10	8	8	1	1	1	1	2,142

[1] Excludes 1 launch made for the United States by Italy.
[2] Includes 1 launch made by Italy for the United States.

See notes at pp. 26–27.

TABLE 2.—WORLDWIDE RECORD OF KNOWN SPACE LAUNCHINGS—FAILURES (INCOMPLETE)

Year	United States	U.S.S.R.[1]	Japan	France	China[1]	European Launch Development Organization	European Space Agency	India	United Kingdom	World total[1]
1957	1									1
1958	12									12
1959	10									10
1960	13									13
1961	12									12
1962	7	2								9
1963	8									8
1964	7									7
1965	7									7
1966	4		2							6
1967	3		1							4
1968	3					1				4
1969	1		1			1				3
1970	1		1			1			1	4
1971	3			1		1				5
1972	2									2
1973	2			1						3
1974	1									1
1975	3	2								5
1976			1							1
1977	2									2
1978	1									1
1979					1			1		2
1980	2						1			3
Total	105	185	6	2	1+	4	1	1	1	306

[1] Data for the U.S.S.R., China, and World total are incomplete, but have been estimated by applying the U.S. failure ratio to the corresponding launch totals for the countries in question.

See notes at pp. 26–27.

TABLE 3.—WORLDWIDE RECORD OF PAYLOADS TO EARTH ORBIT—SUCCESSES

Year	United States	U.S.S.R.	Japan	France	China	Italy	European Space Agency	India	Australia	United Kingdom	World total
1957		2									2
1958	5	1									6
1959	9										9
1960	16	3									19
1961	35	7									42
1962	55	25									80
1963	62	19									81
1964	69	37									106
1965	93	69		1							163
1966	94	47		1							142
1967	78	74		2		1			1		156
1968	61	81									142
1969	58	76									134
1970	[1] 35	98	1	3	1	[2] 1					139
1971	[1] 44	107	2	1	1	[2] 2				1	158
1972	[1] 32	106	1			[2] 1					140
1973	23	123									146
1974	27	111	1			2					141
1975	[1] 29	136	2	4	3	[1] 1					175
1976	33	139	1		2						175
1977	27	125	2								154
1978	34	138	3		1						176
1979	18	126	2				1				147
1980	16	132	2					1			151
Total	953	1,782	17	12	8	8	1	1	1	1	2,784

[1] Excludes 1 payload launched by Italy for the United States.

[2] Includes 1 payload launched by Italy for the United States.

See notes at pp. 26–27.

TABLE 4.—WORLDWIDE RECORD OF PAYLOADS TO EARTH ORBIT—FAILURES (INCOMPLETE)

Year	United States	U.S.S.R. [1]	Japan	France	China [1]	European Launch Development Organization	European Space Agency	India	United Kindom	World Total [1]
1957	1									1
1958	8									8
1959	9									9
1960	12	2								14
1961	12									12
1962	12									12
1963	11									11
1964	8									8
1965	7									7
1966	12		2							14
1967	4		1							5
1968	15					1				16
1969	1		1			1				3
1970	1		1			1			1	4
1971	2			1		1				4
1972	2									2
1973	2			2						4
1974	2									2
1975	4	2								6
1976			1							1
1977	2									2
1978	2									2
1979					1			1		2
1980	4						3			7
Total	133	248	6	3	1+	4	3	1	1	400

[1] Incomplete, but totals estimated by applying the U.S. failure ratio to the two countries in question.

See notes at pp. 26–27.

TABLE 5.—WORLDWIDE RECORD OF LAUNCHINGS AND PAYLOADS TO LUNAR ORBIT DISTANCE AND BEYOND—SUCCESSES AND FAILURES

Year	Launchings—Successes			Failures			Payloads—Successes				Failures		
	United States	U.S.S.R.	Total	United States	U.S.S.R. [1]	Total [1]	United States	U.S.S.R.	Germany	Total	United States	U.S.S.R. [1]	Total [1]
1957													
1958				4		4					4		4
1959	1	3	4	2		2	1	3		4	2		2
1960	1		1	2	2	4	1			1	2	2	4
1961		1	1	2	1	3		1		1	2	1	3
1962	4	1	5	1	5	6	4	1		5	1	5	6
1963		1	1		2	2		1		1		2	2
1964	4	2	6		1	1	4	2		6		1	1
1965	4	7	11	1	2	3	4	7		11	1	2	3
1966	7	5	12	1	1	2	7	5		12	1	1	2
1967	10	1	11		3	3	10	1		11		3	3
1968	3	4	7				3	4		7			
1969	5	4	9	1	2	3	8	4		12	1	2	3
1970	1	4	5		1	1	3	5		8		1	1
1971	3	4	7	1	1	2	8	7		15	1	1	2
1972	3	2	5		1	1	8	3		11		1	1
1973	3	5	7				3	7		10			
1974	1	2	3				1	3	([2])	4			
1975	2	2	4				4	4		8			
1976	1	1	2				1	2	([2])	3			
1977	2		2				2			2			
1978	3	2	5				7	4		11			
1979													
1980													
Total	58	51	109	15	22+	37+	79	64		143	15	22+	37+

[1] Incomplete.

[2] German payload launched by United States and included in U.S. data.

See notes at pp. 26–27.

TABLE 6.—WORLDWIDE RECORD OF LAUNCHINGS AND PAYLOADS—EARTH ORBITAL AND LUNAR DISTANCE OR BEYOND

Year	Launches						Payloads					
	Earth orbital success	Lunar distance success	Total success	Earth orbital failure	Lunar distance failure	Total failure	Earth orbital success	Lunar distance success	Total success	Earth orbital failure	Lunar distance failure	Total failure
1957	2		2	1		1	2		2	1		1
1958	6		6	8	4	12	6		6	8	4	12
1959	9	4	13	8	2	10	9	4	13	9	2	11
1960	18	1	19	9	4	13	19	1	20	14	4	18
1961	34	1	35	9	3	12	42	1	43	12	3	15
1962	67	5	72	3	6	9	80	5	85	12	6	18
1963	54	1	55	6	2	8	81	1	82	11	2	13
1964	81	6	87	6	1	7	106	6	112	8	1	9
1965	101	11	112	4	3	7	163	11	174	7	3	10
1966	106	12	118	4	2	6	142	12	154	14	2	16
1967	116	11	127	1	3	4	156	11	167	5	3	8
1968	112	7	119	4		4	142	7	149	16		16
1969	101	9	110		3	3	134	12	146	3	3	6
1970	109	5	114	3	1	4	139	8	147	4	1	5
1971	113	7	120	3	2	5	158	15	173	4	2	6
1972	101	5	106	1	1	2	140	11	151	2	1	3
1973	102	7	109	3		3	146	10	156	4		4
1974	103	3	106	1		1	141	4	145	2		2
1975	121	4	125	5		5	175	8	183	6		6
1976	126	2	128	1		1	175	3	178	1		1
1977	122	2	124	2		2	154	2	156	2		2
1978	119	5	124	1		1	176	11	187	2		2
1979	106		106	2		2	147		147	2		2
1980	105		105	3		3	151		151	7		7
Total	2,033	109	2,142	269	37+	306	2,784	143	2,927	400	37+	437

NOTES

1. Depending on their labels, these tables count either launch events, or separable payloads resulting, either successes or failures. A launch is the expenditure of a rocket (or the application of a reusable vehicle when such is available). Only those flights intended to reach Earth orbit or beyond are included, not planned suborbital flights even by vehicles capable of attaining orbital flight. Orbital flight is defined as any trajectory which would sustain the flight at least for one complete revolution around the Earth unless retrofire is used to bring down the object a little short of a full elipse. While it is possible to sort out flights which reach different kinds of Earth, lunar, planetary, and solar orbits, in the interest of simplicity, the only division used in these tables is between those that successfully circled the Earth, and those that flew as far away as the orbit of the Moon or beyond including "escape" missions that do not return to Earth. Lunar distance flights are counted as "escape" missions because both the United States and Soviet Union have simulated lunar flights to a "phantom" Moon, using vehicles later used for real flights to the Moon. The test of "success" or "failure" is not whether the orbit sought was attained as to its originally intended location, or whether the payload functioned in orbit, merely that an Earth orbit or a distant orbit was attained. In a few instances, a lunar distance or escape failure was an Earth orbit success. A payload is defined as any functional object with a role to play in space other than being an expended rocket casing, shroud, yo-yo weight, or other piece of debris. When a given launching is known to have been intended to separate into more than one useful payload, this payload count is used, even if in a few instances the intended separation failed to occur.

2. At best any such table in an environment of incomplete disclosure can only be generally indicative. The most glaring gap in information is the failure of the U.S.S.R. and the Peoples Republic of China to announce failures on a routine basis. Only one Soviet failure to attain Earth orbit has been announced, while two other such failures were publicised officially by the U.S. Government, and a fourth Soviet failure became known because it was an international flight. A number of other Soviet launches have been identifiable to a high degree of confidence as escape (lunar distance or beyond) failures which were successful in reaching Earth orbit. These were identifiable because of the multiple evidence, depending on the occasion, of Soviet predictions of intentions to make particular flights, the timing of launches which coincide with the appropriate hour and minute for making such long distance flights, and the tell-tale evidence of debris in orbit from which no scientific findings result in the literature afterwards. To bring an approximate balance to the totals in the tables, Soviet failures have been estimated as proportional to the number of flight successes, applying the same percentages as apply overall to the United States success-failure ratio. This may in fact overstate or understate the degree of Soviet failures, but because essentially the same flight principles are being applied in each country, presumably with similar attention to trying to achieve success, this arbitrary calculation should not be far off. Similar information policies are followed in China, and the only failure listed is one which is based on the Chinese announcement that there would be a launch, and the Soviet followup report that the Chinese on that occasion had failed. While the record of U.S. failures is probably complete, it should not be assumed that a complete tabulation came easily. All U.S. launches are announced at the launch site, but not always picked up routinely by national news media. Failures are sometimes found by noting a discrepancy between local launch announcements and the count of objects later reported to be in orbit. While the same ratio has been applied to the known Chinese launch success record, the total count is too small to have any statistical validity to coming very close to the actual failure rate, especially as failure rates tend to be higher in the early part of a space program than in a more completely developed one.

3. An arbitrary decision has been made to count Soviet orbital launch platforms as payloads in Earth orbit. Each of these is called a Tyazheliy Sputnik by the U.S.S.R., and is separate and distinct from the expended body of the carrier rocket. At least in the early days, the Tyazheliy Sputnik sent back its own radio signals and telemetry. Such platforms are used for the bulk of flights to very eccentric Earth orbit, to geosynchronous orbit, to the Moon and to the planets. In the interest of simplicity in these tables, data on such launch platforms are not shown separately, but are identified in later tables that break down Soviet flights by payload mission. There have been 203 Tyazheliy Sputnik payloads in Earth orbit, not counting possible platforms used with some "F" class launch vehicles.

4. The record by country in these tables is strictly by launching country, regardless of for whom the payload was launched. As a matter of convenience in reference,

the four launches and matching four payloads sent to orbit by Italy for the United States are flagged. Following tables identify more generally international launch services in those cases where whole payloads were launched by one country for another; but those tables make no attempt to identify cases where an individual experiment of another country was only a subcomponent of the primary country's payload.

5. The reason that it is not possible to estimate total Soviet launch and payload failures to lunar distances or beyond by the same methodology used for Earth orbital flights is because the known number of such failures exceeds the expected ratio derived from the U.S. experience. This does not of itself lead to the conclusion that the Soviet Earth orbit failure count should be higher than given, because the Soviet flights which use the orbital launch platform technique carry a higher risk of failure for many of those missions than the United States faces with its lower latitude launch site at Cape Canaveral, which permits simpler procedures for geostationary or escape missions.

6. The payload counts exceed the launch counts because it is not uncommon for a given launch vehicle to be used for orbiting several payloads. Usually the separate payloads are each assigned a national catalog number or an international designator. But in some cases, even though the identity of these separate payloads is well known, the catalogs are not consistent in accounting for all of them. Also, a particular problem is presented by Soviet pickaback payloads. Few have been acknowledged by the U.S.S.R., yet the separated objects are routinely tracked and cataloged by Western detection systems. In some instances, it is difficult in the absence of definitive information to decide which separated objects are functional pickabacks, properly counted as payloads, which are maneuvering engines, counted as expended rockets, and which are miscellaneous pieces of debris. There may be some statistical validity to the overall counts if any errors of individual identification are offset by opposite errors.

7. In a limited number of cases, some payloads intended to fly to lunar distance or beyond became failures in that category because they stayed in low Earth orbit, but were counted as orbital successes. This happened twice in the U.S. program, and probably 20 times in the Soviet program. Also, the tables do not reflect one U.S. escape flight where the payload was successful in reaching Earth orbit as intended, but an unreported expended rocket body was deliberately sent to escape speed.

SOURCES.—Data on successful flights are derived from a combination of flight registrations in records of the United Nations, the logs of the Royal Aircraft Establishment, and the Goddard Satellite Situation Reports, with slight modifications through interpretation of raw data. The failure record for the United States is partly derivable from United Nations records, and more from the annual report of the President to Congress on aeronautical and space activities. Failures for most other countries have been reported in the trade press or in reports of the launching countries. The notable exceptions have been the U.S.S.R. and the Peoples Republic of China which have elected not to report failures as a general rule. The notes given above explain how such failure totals can be estimated.

In 1962 the United States launched payloads for Canada and the United Kingdom and, with the exception of 1963, have launched payloads in each succeeding year for a variety of nations and agencies now totalling 13 in number. In 1969, the Soviet Union inaugurated the Interkosmos program and, 2 years later, extended the service to France and, later, India and Czechoslovakia. In 1970, Italy launched a payload for the United States and France launched a German payload. The European Space Agency's attempt to launch payloads for Germany and Amsat with the second Ariane launch in 1980 met with failure when the booster was destroyed shortly after lift-off.

These launches for other agencies are summarized in tables 7, 8, and 9.

TABLE 7.—SOVIET LAUNCHES OF PAYLOADS FOR OTHER NATIONS—SUCCESSES AND FAILURES (POSSIBLY INCOMPLETE)

Year	Interkosmos	France	India	Czechoslovakia	Total
1957 to 1968					
1969	2				2
1970	2				2
1971	1	1			2
1972	3	1			4
1973	2	1			3
1974	2				2
1975	2+F	1	1		4+F
1976	2				2
1977	1	1			2
1978	1			1	2
1979	2		1		2
1980					
Total	20+1F	5	2	1	28+1F

NOTES:

1. Interkosmos flights include only those under that label, although a few regular Kosmos flights have also been labeled as fulfilling needs of the cooperative Interkosmos program.
2. Known orbital failures (possibly incomplete) are marked with the symbol F.
3. Suborbital Vertikal program space probes (sounding rockets of large size) are not included.
4. Individual experiments carried for France, the United States, Sweden, and others are not reflected.

Source: Appendix III Master Log of Soviet Space Flights.

TABLE 8.—U.S. LAUNCHES OF PAYLOADS FOR OTHER NATIONS—SUCCESSES AND FAILURES

Year	United Kingdom	Canada	Italy	Intelsat	France	Australia	European space research organization or agency	Germany	NATO	Netherlands	Spain	Indonesia	Japan	Total
1957 to 1961														
1962	1	1												2
1963														
1964	1		1											2
1965		1		1	1									3
1966				1										1
1967	1			3			F							4+F
1968				1+F			3							4+F
1969	1	1		3			1	1						7
1970	1	1		3	1				1					7
1971	1			2	1				1					5
1972		1		2			3	1						7
1973		1		1										2
1974	3			1	*1			*2		1	1			9
1975		1		2+F	*1		1	*						5+F
1976		1		1				1	1			1		5
1977			1	1+F			3+F		1			1	2	9+2F
1978		1		2			2		1				1	7
1979	1													1
1980				1										1
Total	10	9	2	25+3F	4	1	13+2F	5	5	1	1	2	3	81+5F

NOTES:
1. The * reflects that flights listed for France were joint French/German payloads.
2. Orbital failures are marked with the symbol F.
3. Suborbital flights for Italy and Germany are not included.
4. Individual experiments carried for many countries on U.S. flights are not included.
5. U.S. flights for Germany included in 1974 and in 1976 payloads which entered heliocentric orbits.
6. The European Space Research Organization indicated above was replaced by the European Space Agnecy; NATO refers to the North Atlantic Treaty Organization.

Source: NASA press releases issued at the time of launches.

TABLE 9.—LAUNCHES TO ORBIT PERFORMED BY NON-U.S. AND NON-SOVIET ORGANIZATIONS FOR OTHER NATIONS

Year	Italy for			France for Germany	European Space Agency for		Total
	United Kingdom	United States	Total		Germany	Amsat	
1957 to 1969							
1970		1	1	1			
1971		1	1				
1972		1	1				
1973							
1974	1		1				
1975		1	1				
1976							
1977							
1978							
1979							
1980					F	F	2F
Total	1	4	5	1	1F	1F	2F

NOTES and SOURCES:
1. Orbital successes have been reported in UN space registrations.
2. Orbital failures have been carried in press accounts.
3. Amsat refers to the International Amateur Satellite Organization.

BREAKDOWN BY CATEGORIES

Tables 10 and 11 which follow analyze Soviet and United States payload statistics by the probable mission categories. For a large number of Soviet flights such data are not published, and a variety of analytical techniques have had to be applied to come up with this approximation of the probable missions. Each of these categories will be discussed in some detail further into this section. Some flights can be identified because those of a particular series have been given a specialized name and usually described in fair detail. But most have been thrown under the catchall label "Kosmos"—which means space. The press release issued at many of these launches references the release in 1962 which accompanied Kosmos 1 which listed so many potential missions as to account for almost anything. In the instance of the Kosmos flights, they must be studied for all known characteristics of time and place of launch, of orbital elements, of total time in orbit until decay, and of measurable behavior in orbit. Some of these flights later have their results published in articles in the Soviet scientific journals. Then inferences can be made about others of similar characteristics. For example, years before the United States announced that it had been operating a previously unannounced military weather satellite program, it was evident to close observers that when a succession of payloads were put into 960 kilometer circular orbits, just retrograde enough to be Sun-synchronous, this would almost have to be for the purpose of taking low resolution pictures such as those used for weather reporting purposes. Likewise, when the Soviet Union puts up heavy satellites about 30 times a year and calls them down from low circular orbit after only a few weeks in orbit, one has to think of high resolution pictures recorded on film which will be analyzed in laboratories on Earth. Similar assessments based on logic and inference give a fair basis for defining the missions of most spacecraft.

There are inevitably some arbitrary classification problems. For example, should the first flight in a new series only later defined and made fully functional be classed with that series, or listed under "vehicle tests"? In general, the decision has been to list them with the emerging program. Then there are flights which may serve at least two major purposes. Here somewhat arbitrary choices have been made based upon the best estimate of the dominant purpose.

Table 12 in effect provides some of the backup for table 10 by listing all Soviet flights by years, but grouping them by the names if any assigned by the Soviet Government itself.

TABLE 10.—SUMMARY OF SOVIET SPACE PAYLOADS BY MISSION CATEGORY (WITH U.S. COMPARISONS) IN YEARS

Mission category	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total	
																									Soviet	U.S.
Primarily civilian:																										
Launch platforms					2	6	3	4	11	8	9	8	8	12	10	12	15	11	16	14	12	13	12	17	203	
Science	1	1				7	2	8	5	4	4	11	4	10	8	13	11	9	15	8	14	10	15	6	166	171
Engineering																1			1						2	28
Vehicle tests							1	4	7	1											3				16	11
Communications								1	2	2	3	3	2	5	3	6	8	8	11	11	8	10	10	11	104	153
Weather							2	1	2	2	4	2	2	5	4	3	2	5	4	3	4	1	3	2	51	78
Geodesy												2	2		2	2	1	2	2	1	2	2			18	19
Earth resources																						1	1	1	3	5
Man-related	1			3	2			1	1	2	4	4		1	2	1	5	5	3	3	2	7	8	4	59	13
Manned					2	2	2	1	1		1	1	5	1	3		2	5	3	4	4	5	3	6	51	20
Lunar man-related											2	3	1	2											8	17
Lunar manned																										20
Moon (automated)		3					2		5	6		1	3	3	3	2	1	3		2					34	25
Inward planets					2	3	1	2	3		2		2	2		2			4			4			27	15
Outward planets						3		1	1						5		6								16	15
Subtotal	2	1	3	3	8	21	13	23	38	25	29	35	29	41	40	42	51	48	59	46	49	53	52	47	758	590
Primarily military:																										
Reconnaissance						5	7	12	17	21	22	29	32	29	28	29	35	28	34	34	33	35	36	35	501	231
Calibration								2	5	4	8	9	12	11	11	9	9	8	6	8	7	2	3	5	119	43
Elint Ferret									1		2	3	2	4	6	5	5	5	5	7	6	6	6	4	67	81
Navigation											1	1	2	3	2	3	3	4	4	7	7	8	6	6	57	40
Tactical communications								2	15		1			9	18	18	25	17	26	27	10	35	19	25	247	
Early warning											1	1				1	1	1	2	1	3	2	2	5	20	39
FOBS										2	9	2	2	2	1										18	
Ocean surveillance											1	1		1	2	1	1	3	4	4	3		2	3	26	12
Targets for ASAT											1	2	1	1	3	1				3	3			1	16	
ASATS												2		2	3					4	4	1		1	17	
Subtotal						5	7	16	38	27	46	50	51	62	74	67	79	66	81	95	76	89	74	85	1,088	446
Total	2	1	3	3	8	26	20	39	76	52	75	85	80	103	114	109	130	114	140	141	125	142	126	132	1,846	1,036

See notes at pp. 34–35.

TABLE 11.—SUMMARY OF U.S. SPACE PAYLOADS BY MISSION CATEGORY (WITH SOVIET COMPARISONS) IN YEARS

Mission category	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total	
																									U.S.	Soviet
Primarily civilian:																										
Launch platforms																										203
Science		4	4	2	7	9	10	11	15	10	11	14	14	4	14	9	2	6	5	4	4	5	6	1	171	166
Engineering					1	1	5	2	5	3	4	3	1	1	2										28	2
Vehicle tests							1	3	5	2															11	16
Communications		1		2	3	3	5	3	7	12	19	11	6	6	6	4	5	8	8	14	7	13	5	5	153	104
Weather				2	1	4	3	5	6	6	6	4	3	5	4	4	2	4	4	3	4	4	2	2	78	51
Geodesy						1		2	6	4	1	1	1	1					1	1					19	18
Earth resources																1			1			3			5	3
Man-related					2			1		8	1		1												13	59
Manned						3	1		5	5							4		2						20	51
Lunar man-related								2	3	1	1	3		1	3	3									17	8
Lunar manned												2	8	2	4	4									20	
Moon (automated)			1		2	3		2	2	5	8	1					1								25	34
Inward planets				1		1			1		1	1					1	1		1		7			15	27
Outward planets								2		1	1		2		1	1	1		4		2				15	16
Subtotal		5	5	7	16	25	25	33	55	57	53	40	36	20	34	26	16	19	25	23	17	32	13	8	590	758
Primarily military:																										
Reconnaissance			5	6	13	26	17	23	21	23	18	16	12	9	7	8	5	5	4	4	3	2	2	2	231	501
Calibration						3	6	3	10	8	4		3		5	1									43	119
Elint Ferret						3	7	9	5	5	7	7	11	4	6	3	3	3	1	1	2	2	1	1	81	67
Navigation				2	3	1	3	3	4	4	4	1	1	1		1	1	1	1	1	2	4		2	40	57
Tactical communications																										247
Early warning				2	3	1	4	2	2	3	2	1	3	5	1	2	1		2	1	1	1	2		39	20
FOBS																										18
Ocean surveillance																			1	4	4			3	12	26
Targets for ASAT																										16
ASATS																										17
Subtotal			5	10	19	34	37	40	42	43	35	25	30	19	19	15	10	9	9	11	12	9	5	8	446	1,088
Total		5	10	17	35	59	62	73	97	100	88	65	66	39	53	41	26	28	34	34	29	41	18	16	1,036	1,846

NOTES

1. These tables were derived by using analytical techniques described in the main body of the report to assign each payload into a probable principal mission category.

2. The subdivisions selected for use in this table were chosen to reflect categories discussed in the text. Even when the missions are understood, some flights serve overlapping purposes, and therefore the dominant use was selected, and it alone, to avoid problems of double counting and tabular complexity.

3. Dates are by calendar year of launch.

4. Categories are a form of shorthand. Launch platforms refer to Tyazheliy Sputnik payloads from which a probe or Zond rocket is fired to carry a final payload to a more remote orbit. Science refers to the making of geophysical, solar, and astronomical measurements from Earth orbit. Engineering refers to payloads designed to test out subsystems such as solar cells or gravity gradient means of attitude stabilization. Vehicle tests refer to flights to exercise new launch vehicle combinations and maneuvers with minimal scientific experiments, if any, on the same flight. Communications refers to flights capable of relaying signals over transoceanic or continental distances. Weather refers to payloads gathering and reporting meteorological data. Geodesy refers to payloads whose primary function is to help to define the geoid and locational grids. Earth resources refers to payloads which are automated and nonrecoverable to gather data about the surface of the Earth including the oceans. Man related includes both precursors to manned orbital flights and flights carrying biological experiments as their main purpose. Manned flights refer to Earth orbital ships whether launched manned or later occupied by men beyond mere unloading. Lunar man related include precursors to manned flights whether in Earth orbit or flying to the Moon. In some cases a given launch can include more than one manned payload, as with the Apollo command module and Apollo lunar module; lunar manned refers to lunar related manned flights whether used in Earth orbit or on lunar flights. (See Table 2-13 for a breakdown of lunar flights by different subcategories.) Inward planets is a shorthand reference to flights to Venus and to Mercury, together with flights intended to explore the interplanetary medium inward toward the Sun; flights intended to make such flights, even if stranded in Earth orbit are included. Outward planets correspondingly covers flights to Mars, Jupiter, and the outer planets, together with those exploring the interplanetary medium beyond the orbit of Earth around the Sun; again, flights intended to fly outward, even if stranded in Earth orbit are included. (See Table 2-18 for a breakdown of escape missions to deep space by different subcategories.) The subtotal is a rough approximation of the part of the respective programs which is generally civilian in nature, even though for example a communications or a weather satellite can be serving a military purpose.

5. Reconnaissance refers to military satellites whose primary purpose is to take photographs in relatively high resolution for return to Earth; such satellites may also do electronic intelligence gathering. Some Soviet flights have been specifically labeled as Earth resources satellites, but for purposes of this classification, if they are short-lived and recovered on Earth, an outside observer cannot really distinguish them from military picturetakers. Calibration is a catchall for minor flights that may be used to exercise ground based radars, or to develop the electronic signature patterns of various shapes and substances in orbit when illuminated electronically from the ground. Elint Ferret refers to electronic intelligence gathering satellites which may monitor or intercept communications, note the frequencies and propagation patterns of ground-based radars, or collect any other man-made electronic emissions. Navigation refers to "lighthouses in the sky" whose signals define their own position very precisely, and make it possible for ships or aircraft to measure precisely their own position in relation to the navigation satellite; again, some may be serving civilian purposes, but historically most have been used primarily by the military. Tactical communications refers to satellites which fly in a relatively low orbit where they can serve theater communications relay needs, or in some instances accept messages for storage on tape and later dumping on command. Early warning refers to satellites whose function is to note and track missile and space launchings largely through infrared signatures. FOBS is the abbreviation for Fractional Orbit Bombardment Satellite System, potentially capable of placing nuclear weapons into a low circular orbit from which the warhead can be called back to Earth short of one orbit if so commanded. Ocean surveillance refers to military systems using active (RORSAT) or passive (EORSAT) means to identify and track ships, particularly naval, on the high seas. Targets for ASAT refers to diagnostic targets placed into various kinds of orbits to be used to exercise military intercept systems. ASATs refer to Antisatellites, payloads capable of maneuvers to intercept,

sometimes inspect, and then to destroy their targets. The subtotal is a rough approximation of the part of the respective programs which are generally military in nature, even though a reconnaissance or navigation satellite might serve an economic purpose.

6. Note that while table 10 summarizes the Soviet program, and table 11 the U.S. program, with data by years, for convenience the totals are matched by the corresponding totals for the other country for ease of comparison.

SOURCES.—This table draws upon the basic log of all Soviet space flights contained in appendix III, and upon the corresponding log (updated) appearing in the study U.S. Civil Space Programs, published by the House Committee on Science and Technology in 1980. In general, classification of flights results from a synergistic analysis of data in these major logs with the chapters of interpretation in the main body of the respective studies, noting repetitive patterns of orbital parameters and use of particular launch vehicles to match against the smaller number of flights whose missions are known, so that by analogy the unknowns can be assigned to mission categories.

TABLE 12.—SUMMARY OF SOVIET SPACE PAYLOADS BY NAME IN YEARS

Name	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total
Sputnik	2	1																							3
Luna			3				1		4	5		1	1	2	2	1	1	2		1					24
Korabl Sputnik				3	2																				5
Tyazheliy Sputnik					1																				1
Venera					1				2		1		2	1		1			2			2			12
Vostok					2	2	2																		6
Kosmos						12	12	27	52	34	61	64	55	72	81	72	85	74	85	101	86	96	79	88	1,236
Unannounced and Pickabacks					1	5	1		1	2		3	2	3	7	8	8	8	13	6	8	9	12	5	102
Mars						1									2		4								7
Polet							1	1																	2
Elektron								4																	4
Zond								2	1			3	1	1											8
Voskhod								1	1																2
Molniya 1									2	2	3	3	2	5	2	3	4	2	3	4	3	4	3	3	48
Proton									2	1		1													4
Soyuz											1	2	5	1	2		2	3	4	3	3	5	3	4	38
Meteor 1													2	4	4	3	2	5	3	3	2		1	1	30
Interkosmos													2	2	1	3	2	2	2	2	1	1	2		20
Salyut															1		1	2		1	1				6
Molniya 2															1	3	4	3	4	1	1				17
Oreol (Aureole)															1		1								2
MAS (SRET)																1			1						2
Prognoz																2	1		1	1	1	1		1	8
Molniya 1-S																		1							1
Molniya 3																		1	3	2	2	2	2	1	13
Ariabat (Aryabhata)																			1						1
Meteor 2																			1		2		2	1	6
Raduga																			1	1	1	1	1	2	7
Ekran																				1	1		2	2	6
Sneg (Signe)																					1				1
Progress																						4	3	4	11
Radio																						2			2
Magion																						1			1
Gorizont																						1	2	1	4
Bhaskara																							1		1
Soyuz T																							1	2	3
Subtotal	2	1	3	3	7	20	17	35	65	44	66	77	72	91	104	97	115	103	124	127	113	129	114	115	1,644
Implicit Tyazheliy Sputniks					1	6	3	4	11	8	9	8	8	12	10	12	15	11	16	14	12	13	12	17	202
Total	2	1	3	3	8	26	20	39	76	52	75	85	80	103	114	109	130	114	140	141	125	142	126	132	1,846

See notes p. 37.

NOTES

1. This is a straightforward listing of Soviet payloads by the names announced by the Soviet Tass agency (plus those unannounced and hence nameless) in the order of appearance of names.

2. The unannounced payloads have been included so that the table will match the totals shown in other tables, and these are flights either discovered by Western sensors, or inferred from the nature of the flights.

3. The use of orbital launch platforms under the name Tyazheliy Sputnik, used for making flights to the Moon or planets, and to eccentric or geostationary Earth orbit are often announced as functionally present, but are no longer assigned sequential numbers by Tass, hence are shown in a separate line at the bottom of the table.

4. Tass has also used the label Sputnik in a generic sense, but has not continued to apply a sequential number after Sputnik 3, although some Western authorities continued to apply such Sputnik numbers to a variety of Soviet payloads, making for confusion (i.e., Korabl Sputnik 1 called Sputnik 4 in the West, and Tyazheliy Sputnik 4 called Sputnik 7 in the West). Also, the Russians did refer to Venera 1 as being launched from Tyazheliy Sputnik 5, which in this table is listed with other implicit or unnumbered Tyazheliy Sputniks. The Russians also refer generically to deep space or eccentric orbit flights as Zonds or probes, but have used the name with a sequence number in only eight cases.

5. Raduga, Ekran, and Gorizont flights are also referred to by Tass according to their international registration Statsionar position indicators.

6. The only launches to orbit completely ignored by Tass are three Venus attempts, and two Mars attempts all of 1962, one Moon attempt of 1963, all stranded in Earth orbit, and two FOBS-related flights in 1966. In addition, to the announced count, but not totally ignored, are the first Venera payload of 1961, not separated from Tyazheliy Sputnik 4. From 1965 on, there have been pickabacks associated with a number of Kosmos flights, discovered by Western sensors, with a very few such pickabacks shown in static displays of hardware by the Soviet authorities. As explained elsewhere, the count of such pickabacks in individual years may be in error, because it is hard to distinguish among pickabacks, maneuvering engines discarded, and miscellaneous space debris, but the overall count may be approximately right. The count of functional payloads for purposes of this table also run slightly higher than the Tass designations by sequence numbers because of such extra objects such as planetary craft dividing into orbital buses and surface landers; or lunar landers and Earth return sample carriers. Such extra acknowledged but unnumbered craft are added to the pickaback count in the table.

7. Wherever identifiable, the count includes payloads which were intended to separate from other payloads whether in fact they did or did not.

SOURCES.—Tass bulletins for the majority, with unannounced payloads as listed in appendix A of this study.

COMPARATIVE WEIGHTS OF PAYLOAD

There is no certain way of finding out the exact weights [2] of payload carried to orbit by each nation as only selectively is such information released by the governments concerned. Further, the actual weights of payload, announced or estimated, suffer from two statistical problems. There is no universal definition of what constitutes payload, and the significance of a given payload weight is modified by the velocity imparted to it.

A payload may be defined by some reports as the total weight sent to orbit, and by other reports as the weight above the accompanying rocket casing. Still others narrow the definition to the specific weight of instrumentation carried in a space vehicle. Illustrative is the variety of numbers associated with an Apollo Moon flight. The typical range of numbers are 136,000 kilograms in Earth orbit, 45,400 kilograms to the vicinity of the Moon, 5,440 kilograms returned to Earth, for a crew, some rocks, and film with an approximate weight of perhaps 400 kilograms.

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[2] Strictly speaking one should distinguish between the meanings of mass and weight. The weight of a body is the force exerted upon it by the gravitational field in which it finds itself. At the Earth's surface a body of mass 1 kilogram has a weight of 9.8 newtons. This is loosely referred to as a "weight of 1 kilogram." It may be useful to think of the weight as the force that needs to be overcome by a launch from the Earth's surface in order to put a given mass into orbit.

The amount of payload carried by a given rocket is subject to division of weight carrying capacity between fuel to attain a given velocity in order to reach certain altitudes or inclinations, and the useful payload of the vehicle structure and its instrumentation or passengers. A given rocket will place the largest amount of weight in orbit by being fired due east from an equatorial launch site, because the rotational speed of the Earth, some 0.465 km/s, is added to the rocket speed. All launches from sites closer to the poles or at higher inclinations if posigrade put up less payload. The use of retrograde orbits at any inclination exacts a carrying penalty by working in opposition to the rotation of the Earth.

Being mindful of these several qualifications, perhaps the most useful kind of comparison is to estimate the weights of payload which could be put into a low circular orbit, which reflects in a sense the potential payload capacity of each launch, even if in a particular case payload was traded for more fuel to send the lighter payload to higher orbit or to escape. We are handicapped in compiling such statistics related to total weight by other problems. For some vehicles, we do not have definitive information on their lifting capabilities (see the discussion which follows on each Soviet vehicle). Further, even when we know something about vehicles, such as those of the United States, there are constant technical changes being made and the precise characteristics of even the seemingly known vehicles may not really be known to the outsider. Most striking are the kinds of changes which have occurred in the Thor Delta family whose capacity ranged from a few hundred kilograms in the early days to a spread today up to thousands of kilograms, depending upon the length of main tank, and the number of solid fuel strap-ons.

Table 13 which follows is offered with some reservation because it is so approximate, but it probably is generally indicative of trends. It assumes an approximate average capacity for each launch vehicle used, and applies this to the number of launches each year from each country. The table has not been further refined to convert the comparisons to a uniform eastward equatorial launch; rather, it accepts as the average the site of Tyuratam as the best Soviet site at about 45.6 degrees north latitude, and Cape Canaveral as the best U.S. site at about 28.5 degrees north latitude. Hence the table is not a measure of any actual weight of payload, whatever that definition. It represents some kind of a normalized maximum carrying capacity of rockets to place spacecraft in an orbit of about 185 or 200 kilometers above the Earth, firing due east from the named launch sites or their other national equivalents.

TABLE 13.—WORLD TABLE OF PAYLOAD WEIGHT TO ORBIT OR BEYOND

[Based on nominal lift capacity in kilograms of launch vehicles to 200 kilometer circular orbit]

Year	U.S.S.R.	United States	China	Japan	European Space Agency	Italy	France	United Kigdom	Australia	India	Total
1957	4,000										4,000
1958	2,000	1,320									3,320
1959	13,500	3,660									17,160
1960	13,500	9,460									22,960
1961	33,000	32,120									55,120
1962	77,910	60,990									138,900
1963	72,270	49,570									121,840
1964	128,410	118,000									246,410
1965	251,900	163,480					50				425,430
1966	241,800	204,750					50				446,600
1967	326,100	270,800				150	100		68		597,218
1968	392,800	404,900									797,700
1969	399,230	625,830									1,025,060
1970	423,760	211,280	300	75		180	200				635,795
1971	444,940	357,080	300	300		360	100	120			803,200
1972	377,640	368,240		150		180					746,210
1973	562,100	306,690									868,790
1974	513,940	99,810		200		480					614,430
1955	547,800	165,520	14,250	3,000		240	600				731,410
1976	570,360	135,210	9,500	1,000							716,070
1977	579,220	136,420		1,450							717,090
1978	601,200	157,390	5,000	1,700							765,290
1979	618,000	93,180		1,450	5,500						718,130
1980	615,200	69,210		1,450						42	685,902
Total	7,810,580	4,044,910	29,350	10,775	5,500	1,590	1,100	120	68	42	11,904,035

See notes p. 40.

NOTES

1. There is no way to build a complete and accurate record of actual payload weights carried to orbit when in the majority of cases, no data are supplied by the launching country either of the weight of the payload or the lifting capacity of the launch vehicle; further, there are not even uniform definitions of what constitutes "payload."

2. For most launch vehicles, there are a few data points available at some point in their history of use which can be applied to construct a curve plotting lift capacity with average orbital distance above the Earth's surface, and if the data points are too few, such capacity characteristics can be estimated from the energies required. That is, the weight of payload which can be carried by a given launching rocket is inversely related to the altitude to be attained. This is because payload weight must be traded for extra fuel to attain the longer burn which imparts the higher terminal velocity which will push the rocket and its payload to the higher altitude.

3. The location of the launch site as to latitude and the azimuth used at that site affect the payload which can be carried. At a given launch site, launching due east will permit the carriage of the heaviest payload, because the rotation of the Earth can be added in greatest degree to the speed of the rocket, and the nearer the launch site is to the equator, the higher the increment of speed will be.

4. Over a period of years, some rockets are given technological improvements which enhance their performance, so that it is not enough to identify the class of launch vehicle alone in making estimates of payload capacity.

5. The table developed here has marked limitations, but at least conveys the general dimensions of the logistics effort and resource commitment as far as launch successes are concerned. But it should be understood that the weight totals reported do not represent actual weights, instead representing approximate commitments. That is, estimates have been made for the lift capacity of each rocket used for a successful launch to carry payload to a circular orbit of 200 kilometers above the surface of the Earth when the rocket is launched due east from the lowest latitude launch site of the launching country. Many actual payloads will have weighed less than the table implies, either because payload was traded for fuel, or the launch vehicle was used at less than full capacity for some missions.

6. The total for Italy includes a nominal 780 kilograms launched for the United States.

SOURCES.—The number of flights and the launch vehicles used in the case of the Soviet Union have been derived from appendix III of this report. Similar data for the United States have been compiled from annual reports of the President to Congress on aeronautical and space activities, also as summarized in the study published by the House Science and Technology Committee on U.S. Civilian Space. Corresponding data for other countries were compiled from United Nations registrations and press reports, as summarized in the study Worldwide Space Activities, of the House Science and Technology Committee (updated). Weights applied to these flights have been estimated as described above.

Others have tried to estimate the actual weight of Soviet payloads by use of the small number of data points made available. An ambitious set of such calculations is that by Anthony Kenden of the United Kingdom.[3] Kenden took as a starting point a figure mentioned by the Soviet chief designer of rocket engines, Valentin Glushko, who cited by July 1, 1973, a Soviet total of 742 satellites weighing 2,233 metric tons, and 41 more weighing 110 tons which reached escape velocity. Kenden then examined lifting capacities quoted by the TRW Space Log, Sheldon's previous studies, and those of the tables published by the Royal Aircraft Establishment. He examined in some detail the flights for which there are Soviet published weight figures, those whose weights are fairly readily estimatable, and finally those that are more obscure. By looking at each class of launch vehicle and each type of mission, Kenden built numbers which provided a reasonably good fit with the figure from Glushko. His effort was generally satisfying, although there was one minor flaw. He assumed that certain figures published in the TRW Space Log had been estimated by them on the basis of optical data and decay rates. The figures in question were supplied by Sheldon to TRW, and he in turn obtained them from the publications of the RAE in Great Britain. Hence, although they may be the best numbers obtainable, many of them essentially are estimates made by J. A. Pilkington, and similarities from one source to another are not signs of confirmation but of use of the same original source.

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[3] Kenden, Anthony. An Analysis of the Masses of Russian Spacecraft. London, Spaceflight, Aug./Sept. 1975, pp. 289-297, and 344.

LAUNCH SITES IN THE SOVIET UNION

The Soviet Union has three collections of space launch pads, just as does the United States. Curiously, even the functions of these three locations have a similarity, which will be detailed in the sections to follow.

TYURATAM

The largest and most versatile of the Soviet launch sites is near the rail stop village of Tyuratam in Kazakhstan at about 45.6 N. latitude, 63.4 E. longitude. The Russians call it the Baykonur Cosmodrome, although it is about 370 kilometers southwest of the station stop of that name on quite a different railway line. It originally may have been thought that by giving contradictory information about the cosmodrome, the Russians would maintain some element of doubt in the Western world, since the town of Baykonur is on the correct ground trace of the early Soviet flights which were at 65 inclination. To this day the Russians pinpoint the launch pad for manned flights as being at 47.3 N. and 65.5 E. which is patently false in light of conclusive public evidence of initial revolution ground traces and known launch times. Presumably based upon Soviet data, the NASA press kit for the Apollo-Soyuz Test Project lists the launch site as being at 47.8 N. and 66 E. This does not square with NASA Landsat photographs and the visits and descriptions supplied by NASA visitors to this launch site.[4]

Tyuratam was first accurately placed in public announcements by the optical studies of Prof. Tadao Takenouchi in December 1957, following his observations of Sputnik 1 and 2.[5] The American trade press continued for some years to report the launch site as being in European Russia, until the Russians themselves announced it was in Kazakhstan (albeit at false coordinates, at the time of the Gagarin flight in 1961).

Tyuratam was the site from which the first Soviet ICBM's were fired, all the early Sputniks, all manned flights, all lunar and planetary flights, the earlier communications satellites, all the fractional orbit bombardment system (FOBS) and military imspector flights. It is also the area from which all heavy payloads put up by the Proton "D" type launch vehicle. Presumably, the same site selection reasons recommended Tyuratam as the logical place for the launch of the largest Soviet launch vehicle still under development.

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[4] Aviation Week, New York, Jan. 14, 1974, pp. 12-13, pictures.

[5] Takenouchi, Tadao. A Launch Site in the Kizil Kum Desert? Tokyo, Kagaku Asahi, February 1958, pp. 40-48 (in Japanese); reported earlier in press dispatches.

In effect, Tyuratam is the Kennedy Space Center (Eastern Test Range) of the Soviet space program.

The first good look at the immediate launch site of the standard launch vehicle was provided by a 1967 movie giving an historical review of the Soviet program during the previous 10 years. Those fairly sweeping panoramic views fit consistently with the carefully cropped or pointed views which had been released piecemeal in previous years. Earlier the Russians had disclosed that the historical marker for Sputnik 1 was beside the pad used for manned launches, one more factor confirming the long term use of both the same pad and the same first stage for missions from Sputnik 1 through Soyuz 19, the Apollo-Soyuz Test Project (ASTP) flight. In the fall of 1979, a photograph of the original launch pad, taken from a U-2 during 1959, featured in an exhibition mounted in the National Air and Space Museum's Flight and Arts Gallery under the title "Our Beautiful Earth: The View from Air and Space." [6] Figures 1a and 1b are drawings based on this photograph and Soviet films of the roll-out of the ASTP booster.

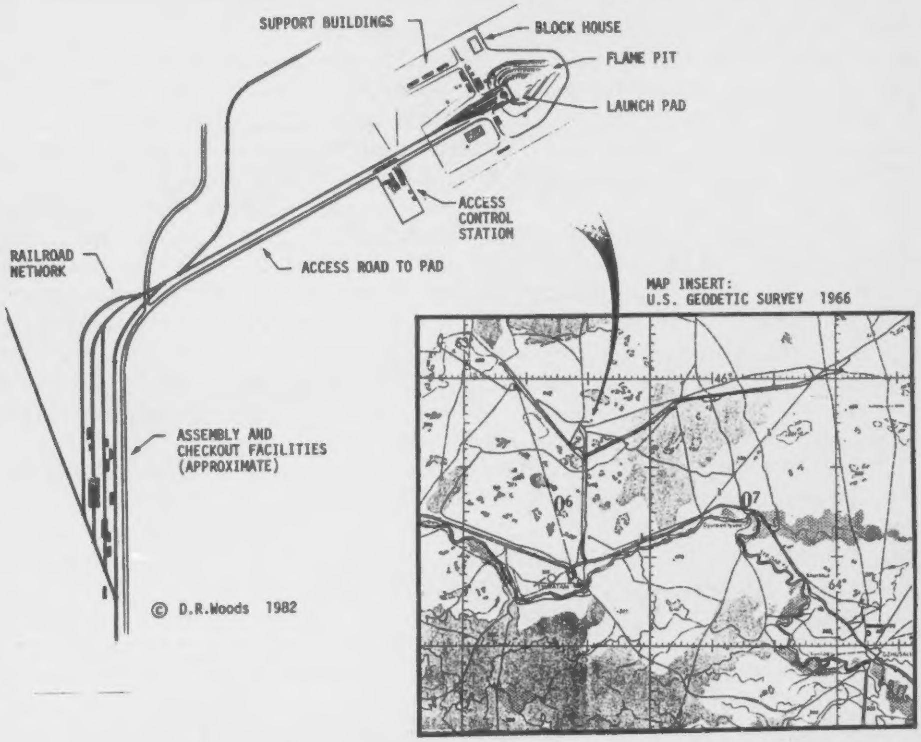
SUPPORT BUILDINGS
BLOCK HOUSE
FLAME PIT
LAUNCH PAD
ACCESS CONTROL STATION
ACCESS ROAD TO PAD
RAILROAD NETWORK
ASSEMBLY AND CHECKOUT FACILITIES (APPROXIMATE)
© D.R.Woods 1982
MAP INSERT: U.S. GEODETIC SURVEY 1966
63
46
06
07
64

FIGURE 1a. Lay-out of original launch pad used to launch Sputnik 1 on October 4, 1957. Insert shows location on later map by the U.S. Geodetic Survey.

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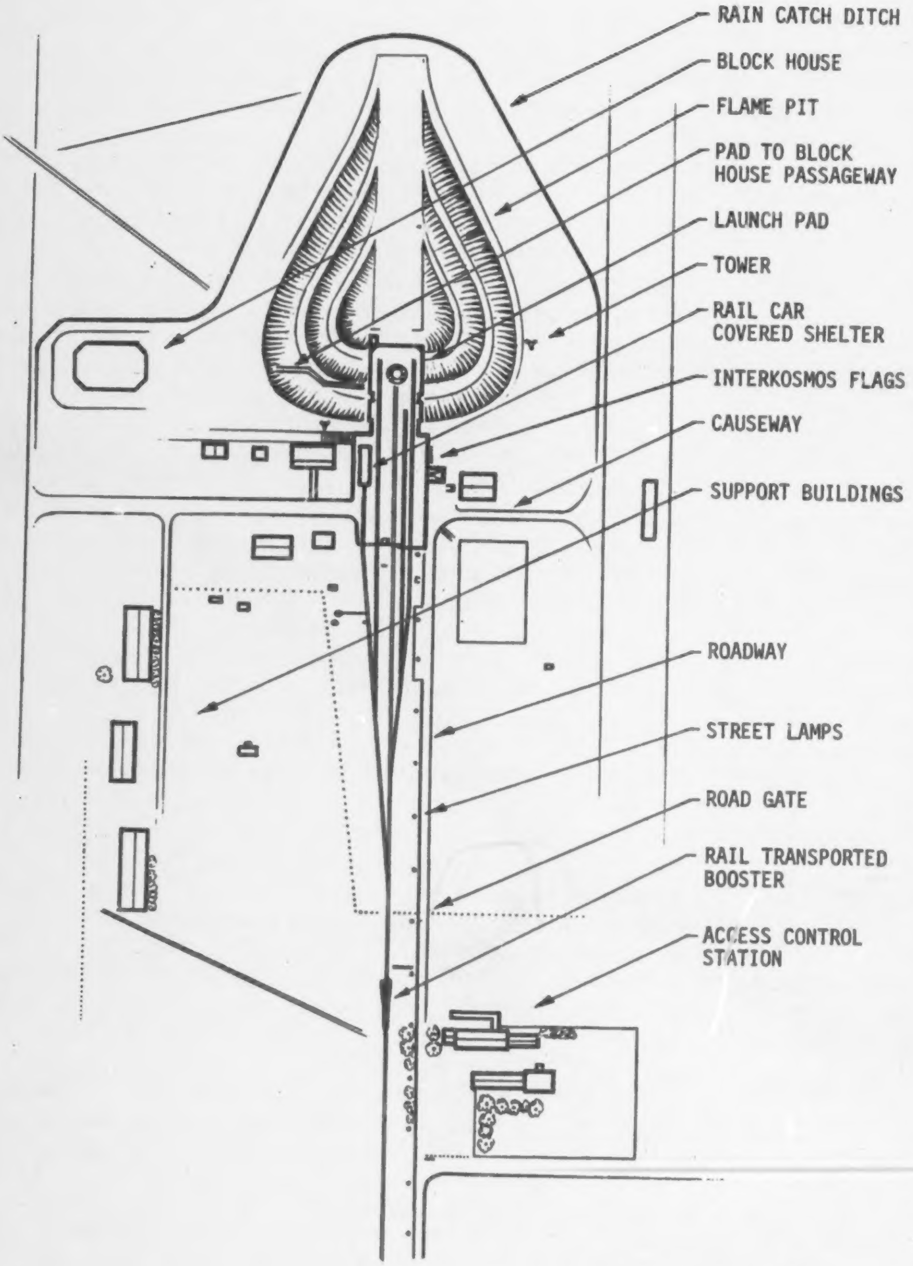
[6] Air and Space, vol. 3, No. 2, pp. 6-7, Nov.-Dec. 1979, National Air and Space Museum, Smithsonian Institution, Washington, D.C.

BEST AVAILABLE COPY


RAIN CATCH DITCH
BLOCK HOUSE
FLAME PIT
PAD TO BLOCK HOUSE PASSAGEWAY
LAUNCH PAD
TOWER
RAIL CAR COVERED SHELTER
INTERKOSMOS FLAGS
CAUSEWAY
SUPPORT BUILDINGS
ROADWAY
STREET LAMPS
ROAD GATE
RAIL TRANSPORTED BOOSTER
ACCESS CONTROL STATION

© D.R.Woods 1982

FIGURE 1b. Detail of A-vehicle launch pad based on a 1959 U-2 photograph released by the CIA, and Soviet films of the ASTP A-booster roll-out in 1975.

For a long time no outsider could get to the launch site. President De Gaulle was taken there in June 1966 to see the launch of the first acknowledged weather satellite (Kosmos 122), accompanied only by his personal physician. In 1970, President Pompidou saw the launch of a military observation satellite (Kosmos 368) which carried a supplemental scientific payload. Finally, in connection with the upcoming ASTP flight, three parties of American astronauts and technicians were flown in at night, put up in a hotel, driven to the launch pad, and then were returned to their hotel for another night flight out.

In the meantime, low resolution pictures made public by NASA routinely to anyone interested showed that the Landsat 1 views of the Tyuratam area were covered with roads, railway tracks, and other signs of human activities including almost certainly assembly buildings and launch pads which spread over a distance of about 135 by 90 kilometers or more. Also, the NASA people flying at night saw a scattering of electric lights from their aircraft that spread over distances of about this amount. At the day of the launch, the American Ambassador, the science attaché, and Willis Shapley of NASA headquarters were flown there in daylight hours for the launch, but did not see too much from the air. People did report that the little railway stop of Tyuratam these days, is completely overwhelmed by the adjacent city of Leninsk, of perhaps 50,000 people. This city has not been shown in public Soviet atlases, and seems to owe its existence to the growing space activity. More recent Landsat imagery suggests that additional development at either extremely has increased the east-west dimension to nearer 150 km. With launch pads for many different launch vehicles widely scattered over the area, it is not possible to speak of a single closely defined latitude and longitude as defining the site, or to know what all the launch facilities look like. The original "A" class standard launch vehicle is carried horizontally on railway flat cars to the launch pad, tilted up, to sit on a stand over a large flame deflector pit. The base of the rocket in the upright position is well below the level of the railways tracks which deliver the rocket. There is a many platformed service tower which is tilted away from the vehicle some time before launch, and shorter supports for the first stage which retract away after ignition when thrust reaches a certain level. Tall adjacent lightweight structures are described as carrying lightning rods to minimize electrical interference with the launch equipment and vehicle, and perhaps to carry television or motion picture equipment.

At the time of ASTP the Soviet Union stressed their intention to have a backup Soyuz spacecraft, launcher and crew ready and waiting on a separate pad to ensure their ability to honor their commitment to launch, should a major problem prevent the launching of the prime crew. The distance between the two pads was said to be about 30 km. A study of official Soviet photographs of various launches enabled Nicholas Johnson to distinguish major differences between the two pads by considering the positioning of the lightning conductor towers, nearby buildings, and the second pad having the corners above the flame pit chamfered rather than right-angled.[7] Figure 2a and 2b, based on drawings by Richard Escarcega, and reproduced with permission of the British Interplanetary Society, show these differences.

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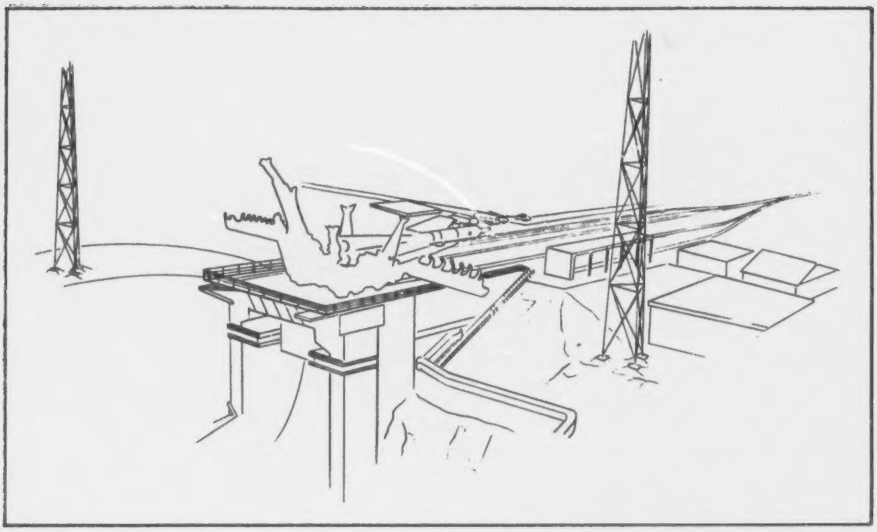
[7] Johnson, Nicholas L. The Baikonur SS-6 Space Launch Facilities, Spaceflight, 23, pp. 109-116, 1981.



© Richard Escarcega 1982

FIGURE 2a. A-vehicle launch pads at Tyuratam. The original pad used for the launch of Sputnik 1 in 1957. A Soyuz launcher is about to be erected at the original SS–6 launch facility, Pad A.

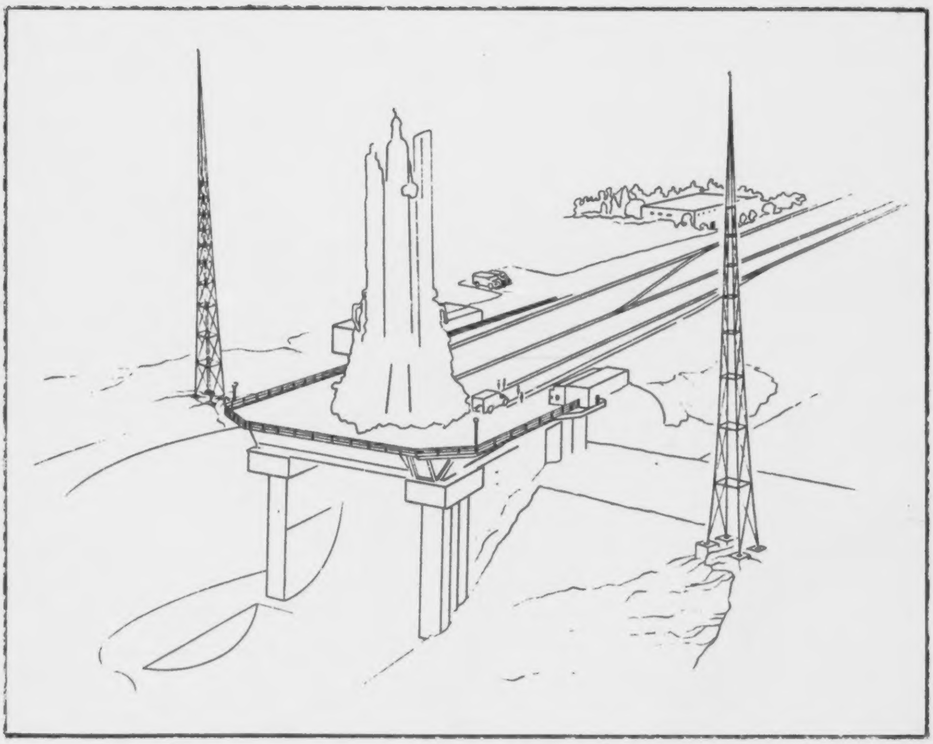


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FIGURE 2b. A second pad which has probably been in use since October 20, 1966, when Kosmos 130 was launched only 1 hour after the fourth Molniya 1, both by A-vehicles from Tyuratam. Pad B, illustrated here, appears to have been built some years after Pad A.

One gains the impression that tracking and guidance of Soviet space vehicles during the launch phase involve fixed radio, radar, and/or optical stations down range. This is because repetitive flights of a given launch vehicle tend to be flown at almost exactly the same orbital inclinations. To achieve the right azimuth for launch, the whole vehicle assembly and platform are rotated to the required compass heading. When two very similar yet different flight inclinations are achieved using different launch vehicles and other evidence supports the judgment, one receives the impression the difference in launch vehicle is also matched by using a different launch pad, and as a result of choice of azimuth to satisfy guidance- and range-safety constraints, the resulting orbit has a slightly different inclination.

Pictures in movies as well as the visits of NASA people show that the assembly of vehicles and the attachment of payloads occurs in special assembly buildings. Checkout of spacecraft is done in the vertical position. Mating of spacecraft and launch vehicles is done horizontally.

Although only one launch pad in a vast cosmodrome has been opened to limited inspection, the Landsat pictures of the whole area confirm the general impression that this is open steppe country, relatively flat and only slightly rolling. There is no basis to the rumors of the early days that Soviet launches were conducted by winged, recoverable booster stages which ran on a track up a mountainside before becoming airborne.

Other Landsat pictures suggest there is a general area in which spent first stages impact on the steppe, and informally Russians in the program have suggested they are able to salvage for reuse some components from this "bone yard."[8]

A Soviet account of the Baykonur Cosmodrome described the assembly-test building used for the Soyuz. The building is called the MIK (Montazhno Ispytatel'nyy Korpus). The article said that a Soyuz is first given a full checkout in the MIK, and then again on the pad. In the MIK, the separate modules are tested in vacuum chambers, including the firing of maneuvering engines. After the individual modules are tested, they are assembled to create the whole vehicle and returned to the vacuum chamber for further checkout. Then they are also placed in an anechoic chamber to test the radio compatibility of the assembled ship with its communications system.[9]

Another account of the Tyuratam complex was carried by Spaceflight. Leninsk was identified as the long referenced "Rocket City" of Soviet accounts, about 2,090 kilometers southeast of Moscow on the main Moscow-Tashkent railway line, with Tyuratam the original village railway stop. The area was described as rolling but mostly flat country, with complex irrigation systems and some tall trees planted. The climate is very extreme summer and winter. It is said to be about 32 kilometers from Leninsk to the ASTP launch pad, and about 1.6 kilometers from the MIK to the pad, using the standard Soviet 5-foot gage railway track to join the two points. The same account said there was a test of the G–1–e.[10]

By studying the Landsat images referred to above and comparing them with large-scale maps of the areas in question, Charles P. Vick has prepared detailed maps of the three Soviet cosmodromes and the launchsite in the People's Republic of China for the Illustrated Encyclopedia of Space Technology.[11] A version of his map of the Tyuratam area is given in figure 3. There is no indication of the large new runway construction reported to have been detected by U.S. reconnaissance spacecraft in 1978, which Aviation Week & Space Technology suggested was being built for the horizontal landing of a reusable winged manned spacecraft under development as the first phase of a Soviet space shuttle program, unless it is the linear feature running from northwest to southeast and terminating near the probable G-vehicle pad.[12] Landsat pictures obtained in 1980 and 1981 indicate that a second linear feature, crossing "M" in figure 3 at right angles, has been paved to the northeast of "M" since 1979. As this is more nearly in line with the launch azimuth, it might eventually prove to be the runway.

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[8] Aviation Week, New York, Feb. 18, 1974, p. 17, pictures of drop area.

[9] Pravda, Moscow, May 25, 1975, pp. 1, 2.

[10] Spaceflight, London, Oct. 11, 1975, p. 368.

[11] The Illustrated Encyclopedia of Space Technology, pp. 39–44, Salamander Books Ltd., London, 1981.

[12] Washington Roundup, Aviation Week & Space Technology, vol. 110, No. 2, p. 11, Jan. 8, 1979.

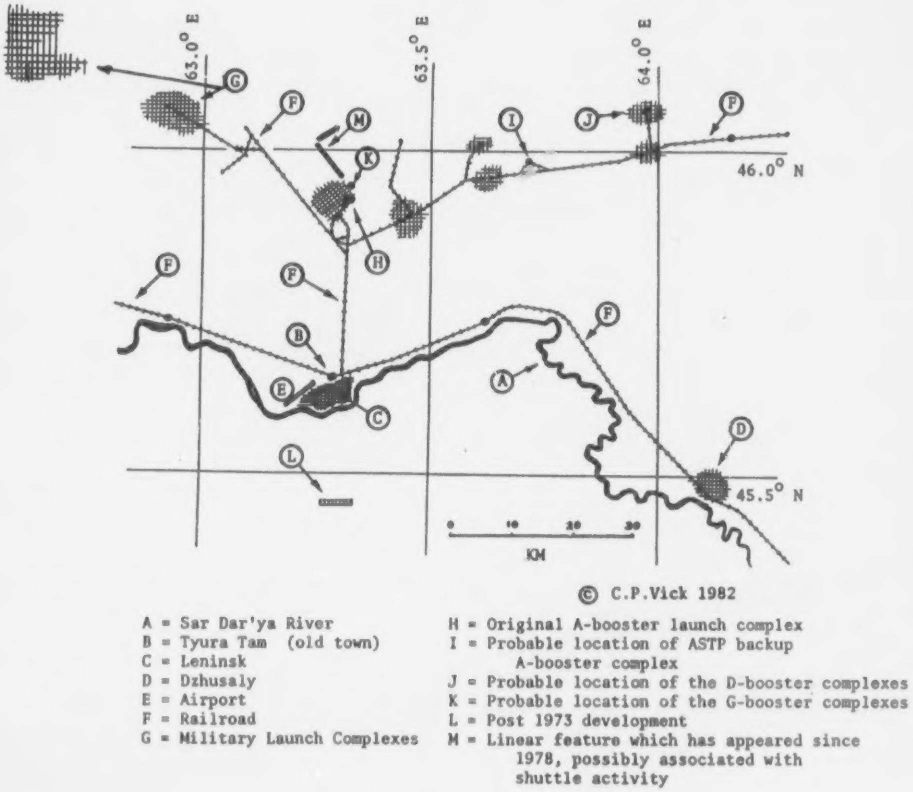
63.0° E
63.5° E
64.0° E
46.0° N
45.5° N
G
F
M
K
I
J
F
H
F
F
F
B
E
C
A
D
L
0 10 20 30
KM
© C.P.Vick 1982
A = Sar Dar'ya River
B = Tyura Tam (old town)
C = Leninsk
D = Dzhusaly
E = Airport
F = Railroad
G = Military Launch Complexes
H = Original A-booster launch complex
I = Probable location of ASTP backup A-booster complex
J = Probable location of the D-booster complexes
K = Probable location of the G-booster complexes
L = Post 1973 development
M = Linear feature which has appeared since 1978, possibly associated with shuttle activity

FIGURE 3. Baykonur Kosmodrome at Tyuratam.

PLESETSK

The second of the Soviet launch sites is near the town of Plesetsk on the railway from Moscow to Archangel at about 62.8 N. latitude, 40.1 E. longitude in European Russia. This site has never been specifically acknowledged. It is finding increasingly heavy use, primarily as an operational site, in contrast to the often experimental or specialized nature of the Tyuratam flights.

Plesetsk is in effect the Vandenberg Air Force Base (Western Test Range) of the Soviet Union. From here are launched many of the navigation satellites, the weather satellites, and the majority of the military satellites for a wide range of purposes. Since mid-1977, most of the Molniya class inclined orbit communications satellites which previously were launched from Tyuratam have also been launched from Plesetsk. With its northern location, Plesetsk is used for missions which require coverage of extensive parts of Earth, since even flights launched due east for maximum payload capacity cover most of the inhabited Earth.

Plesetsk had been discussed in the Western press as a missile launching area. Its later space role presumably was known to Western governments, but the first public disclosure of this space cosmodrome came from the Kettering Grammar School in England. Geoffrey E. Perry published the first clue in April 1966 shortly after the first space launch in March.[13] He published the pinpointed location in November 1966 when flights at different inclinations had established a nodal point of crossing ground traces.[14] As additional kinds of missions were launched from the Plesetsk area, their patterns of orbital inclinations suggested launch pads scattered over a considerable geographic area. Landsat pictures confirmed to the public that Plesetsk was spread over tens of kilometers although not quite as large as the Baykonur Kosmodrome near Tyuratam.[15] A simplified version of Vick's map of the area is given in figure 4.

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[13] Perry, G. E. Flight International, London, Apr. 21, 1966, p. 670.
[14] Perry, G. E. Flight International, London, Nov. 10, 1966, p. 817.
[15] Aviation Week, New York, Apr. 8, 1974, p. 18-20.

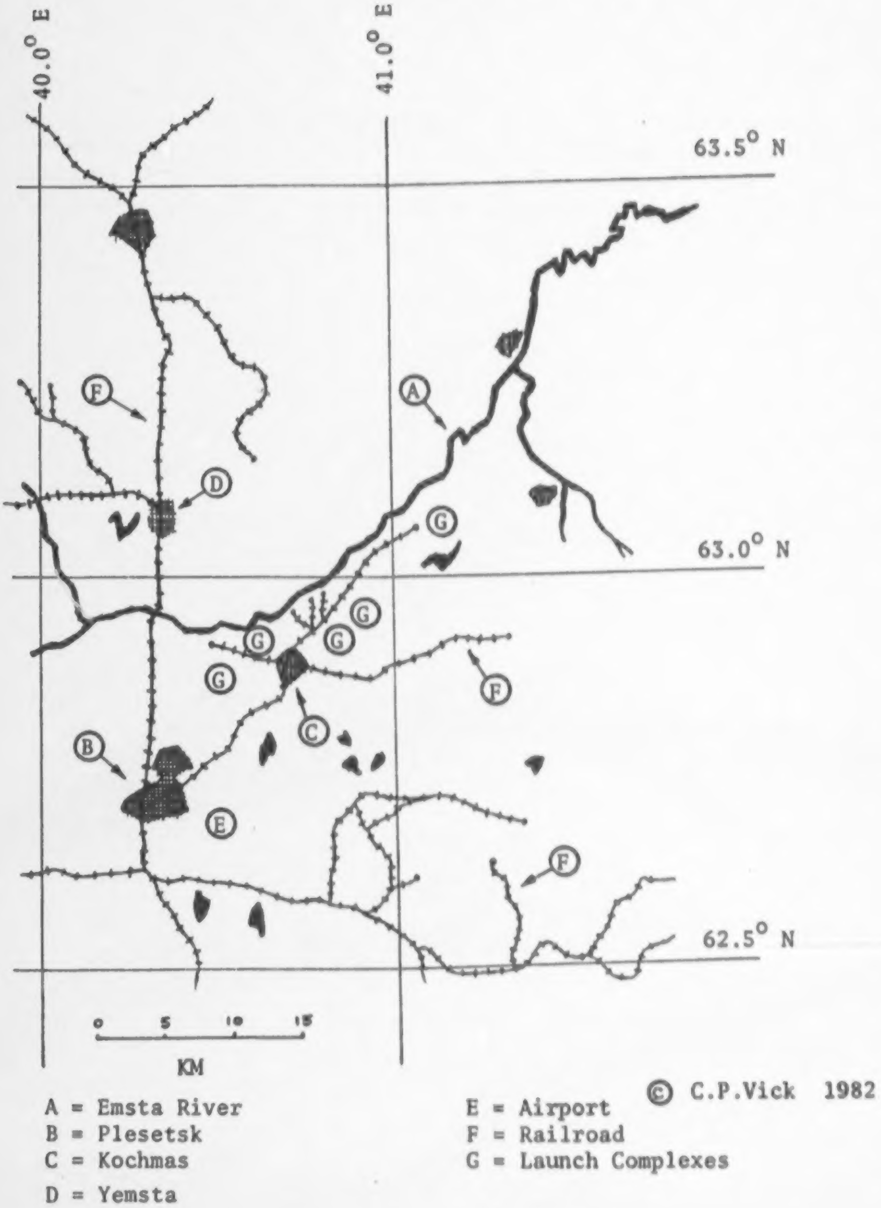
40.0° E
41.0° E
63.5° N
63.0° N
62.5° N
A
B
C
D
E
F
F
F
G
G
G
G
G
G
0
5
10
15
KM
© C.P.Vick 1982
A = Emsta River
B = Plesetsk
C = Kochmas
D = Yemsta
E = Airport
F = Railroad
G = Launch Complexes

FIGURE 4. Northern Kosmodrome at Plesetsk.

When weather conditions are just right, an occasional Plesetsk launch has been visible from Sweden and Finland, when the still firing rocket rises above the horizon. The launch of the seventh Meteor-2 satellite on May 14, 1981, was observed from the roof of the Physics Department of the University of Umea, at 2153 GMT. At the time, the Sun was 10 degrees below the horizon at Umea and 8.4 degrees below the horizon at Plesetsk. The rocket entered sunlight at an altitude of 70 km and rose above the horizon of Umea when it reached an altitude of 85 km. The rocket was observed as coming up vertically relative to the horizon. As it bent over to the north, staging was observed.[16] Susanne Hultman, a student, took a color photograph which was later published by Aviation Week & Space Technology.[17] The gas plume in the picture is over 100 km in length.

An unexplained launch was observed by people in Sweden on their way to work at 0502 GMT on December 22, 1981.[18] On this occasion a smoke trail persisted for 45 minutes implying a high performance solid propellant with a metallic content consistent with a missile test rather than a satellite launch.

The closest the Soviet Government has come to acknowledging Plesetsk is to permit its use for cooperative Soviet bloc payload launches, one of the first being Interkosmos 8 of 1972. Experts of the countries taking part in the Interkosmos program prepare the scientific apparatus for launching at the cosmodrome. Delegations of national dignitaries are also present at the time of the launch. The delegation at the launch of the Intercosmos-Bulgaria 1300 satellite included the Bulgarian cosmonaut, Georgiy Ivanov.[19]

KAPUSTIN YAR

The third Soviet launch site is near Kapustin Yar on the Volga River below the city of Volgograd at about 48.4 N. latitude, 45.8 E. longitude, also in European Russia. Indirectly the site has been finally acknowledged by the Soviet Government, as some suborbital launches in the Vertikal series are referred to as coming from the "Volgograd Station" or, less precisely, "from the middle latitudes of the European part of the U.S.S.R."[20] The area has been used for a long time as a rocket test station. In the middle 1950's before the first Sputnik, Aviation Week magazine revealed the United States had a radar station in Turkey which used radar to follow missile and test rocket firings from this point.[21] Magazines of the period said that Soviet short and medium range missiles were launched southeastward from there toward the Kyzylkum Desert near the Aral Sea as the principal test range. In fact, this launch site was so well known that for several years after 1957, the American press assumed that it was used for the launch of the early Sputniks and Luna flights when in fact they came from the Tyuratam ICBM test center.

It was not until 1962 that payloads were placed in orbit from the Kapustin Yar site, using the smallest of the Soviet launch vehicles, and only in 1973 did they start space launches from Kapustin Yar which used the intermediate size of launch vehicle. All the "B" class small launch vehicles from there put payloads into an inclination of 48.4 to 49 degrees. All the intermediate "C" class vehicles put payloads into an inclination of about 50.7 degrees inclination.

The combination of use of the smaller launch vehicles and the use of the site for launching vertical probes make this site seem to parallel a combination of the Wallops Island, Va. station, and the

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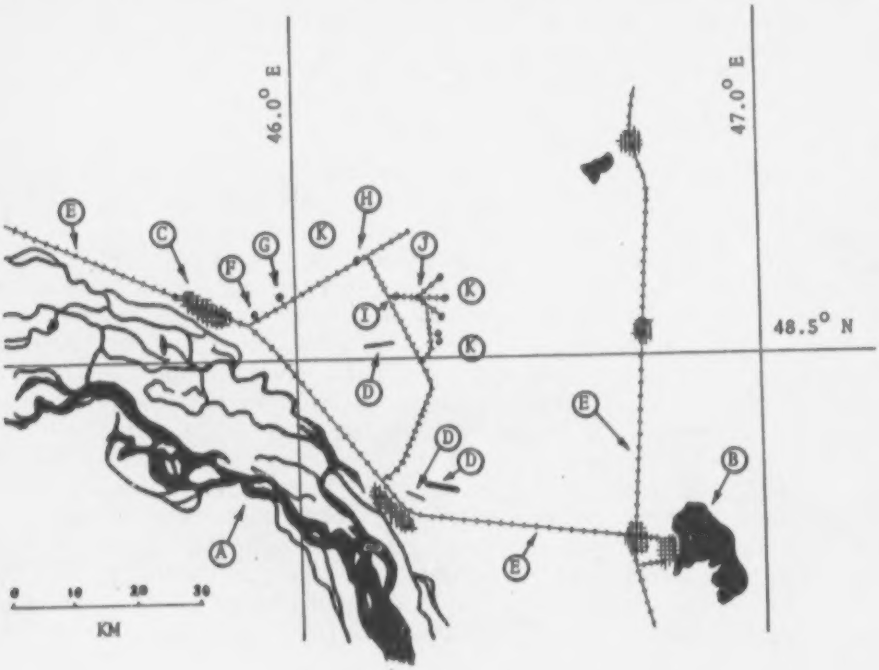
[16] Lindgren, S., private communication to Sven Grahn, June 10, 1981.
[17] Aviation Week & Space Technology, vol. 116, No. 3, Jan. 18, 1982, p. 46.
[18] Norrlandska Social Demokraten, Dec. 23, 1981.
[19] Moscow Home Service, 1700 GMT, Aug. 7, 1981.
[20] Moscow Home Service, 0900 GMT, Aug. 28, 1981.
[21] Aviation Week, New York, Oct. 21, 1957, p. 26.

White Sands, N. Mex. test area. Some Western observers speculated that when the day came that the Soviet Government would ease its security rules sufficiently to open a launch site to outside visitors that Kapustin Yar was most likely to be the first to "go public." This view was encouraged when finally Soviet bloc scientists were permitted to go there in connection with the launch of Interkosmos flights which began in 1969. More recently, engineers and scientists from Sweden, India, and France have also visited Kapustin Yar in connection with the launches of their own payloads and experiments.

Landsat pictures of the area show signs of activity over many kilometers, but not on the scale of Tyuratam or even Plesetsk.[22] Figure 5 is a simplified version of Vick's map of the area.



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A = Volga River
B = Salt Lake
C = Kapustin Yar
D = Airport

E = Railroad
F = Range Headquarters
G = V-2 Monument
H = Guard Gate

I = Horizontal Assembly Building
J = Press Site
K = Launch Complexes

FIGURE 5. Volgograd Station Kosmodrome at Kapustin Yar.

Sary Shagan, the antiballistic missile (ABM) test station to intercept rockets fired from Kapustin Yar, was also found in Landsat pictures.[23]

Table 14 which follows summarizes the known successful launches by site, worldwide, to provide a perspective on their relative levels of activity for orbital launch purposes. The figures do not reveal additional suborbital or missile launchings. The table reveals that Plesetsk has conducted more successful orbital launches than any other base in the world. Tyuratam has pulled ahead of Vandenberg since 1975 and Cape Canaveral is still a poor fourth.

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[22] Aviation Week, New York, Dec. 1, 1975, pp. 18-19.
[23] Aviation Week, New York, Nov. 25, 1974, pp. 20-21.

TABLE 14.—WORLDWIDE RECORD OF ORBITAL AND ESCAPE LAUNCHES BY SITE AND BY YEAR

Launch site	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total
Plesetsk, Russia										6	26	30	37	48	53	52	61	55	62	64	69	61	66	64	754
Tyuratam, Kazakhstan	2	1	3	3	6	13	13	23	41	31	33	36	29	28	29	20	23	25	26	34	27	26	19	24	515
Vandenberg, Calif.			5	7	16	34	27	38	36	43	35	30	22	17	18	19	10	13	12	13	7	14	6	7	429
Cape Canaveral, Fla.		5	5	9	11	17	10	16	24	29	22	14	18	10	10	10	13	9	15	13	17	18	8	6	309
Kapustin Yar, Russia						7	4	7	7	7	7	8	4	5	1	2	2	1	1	1	2	1	2	1	70
Wallops Island, Va.					2	1	1	3	3	1		1		1	2	1							2		18
Uchinoura, Japan														1	2	1		1	1		1	2	1	1	11
Shuang Cheng Zi, China														1	1				3	2		1			8
Indian Ocean Platform, Kenya											1			1	2	1		2	1						8
Kourou, Guyane														2	1				3				1		7
Tanegashima, Japan																			1	1	1	1	1	1	6
Hammaguir, Algeria									1	1	2														4
Woomera, Australia											1				1										2
Sriharikota, India																								1	1
World total	2	6	13	19	35	72	55	87	112	118	127	119	111	113	120	106	109	106	125	128	124	124	106	105	2,142

See notes p. 55.

NOTES

1. This record is of launch "successes" as defined elsewhere in this study; that is, any flight which reached at least one Earth orbit, or which escaped from Earth, either to lunar distance, or to enter solar orbit.

2. Not all launch sites have been announced by the launching country, but most flights can quickly be identified by repetitive use of certain orbital locations. A plot of the ground traces of the "zero revolution" (the initial part of the flight before the Equator is first crossed) will disclose a nodal point which will define that a launch pad is near a certain spot on the surface of the Earth. In occasional instances where a given inclination for an orbit of unknown origin could have come from more than one launch site can still be pinned down by plotting the zero revolution orbital ground trace to observe which launch site falls on this path. In the case of escape missions and geostationary missions, these are already known to have come exclusively from only a few sites (Cape Canaveral, Tyuratam, Tanegashima, and soon, Kourou).

3. The names of launch sites listed are in a sense a kind of shorthand. Plesetsk has never been precisely identified by the U.S.S.R., which refers generally to a northern cosmodrome. The nodal point of the ground traces is near the city of Plesetsk. Tyuratam is officially called the Baykonur Cosmodrome, and the officially listed launch coordinates are several hundred kilometers northwest of the nodal point which is near the railway stop of Tyuratam, and now the growing space city of Leninsk. Vandenberg is the name of an air force base in California near Lompoc, and now expanded to include additional pads at Point Arguello. Cape Canaveral refers to the collection of pads both on the Cape and on nearby Merritt Island, most administered by the Kennedy Space Center. Kapustin Yar is the town nearest the nodal point of launches from a site the U.S.S.R. calls Volga Station. Wallops Island is a NASA site on the Delmarva Peninsula. Uchinoura is a site on Kagoshima Bay, Kyushu. Shuang Cheng Zi is the current spelling of what was Shuang Cheng Tzu in Gansu (formerly Kansu) province. The Indian Ocean Platform also carries the designator San Marco and was constructed by Italy just outside the territorial waters of Kenya. Kourou is in French Guiana. Tanegashima is an island at the northern end of the Ryukyu chain. Hammaguir was the former French site in southern Algeria, later stripped and moved to Kourou. Woomera is in south Australia. Sriharikota is near Madras.

4. The count of launches matches other tables of this study and corresponds to the numbers recorded by COSPAR, the Committee on Space, of ICSU, the International Council of Scientific Unions.

SOURCES.—These have been derived as explained above, and as carried in (updated) logs of studies published by either the Senate Committtee on Aeronautical and Space Sciences, or the House Committee on Science and Technology, derived from United Nations registers, Goddard Satellite Situation Reports, and the logs of the Royal Aircraft Establishment.

SOVIET LAUNCH VEHICLES

OVERVIEW

WORLD RECORD

In the Soviet Union as well as in the United States, the development of military long range missiles was the essential source of most of the space launch vehicles until such time as space needs for larger capacity rockets began to exceed missile capabilities.

However, there was one major difference in their approaches. The United States initially opted for a nonmilitary launch vehicle, the Vanguard, to orbit payloads planned for the International Geophysical Year (IGY). Developed by the Naval Research Laboratory from the scientific Viking and Aerobee sounding rockets, the first orbital attempt failed spectacularly 2 seconds after liftoff on December 6, 1957. Following the successful launch of Explorer 1 by the Army Ballistic Missile Agency on February 1, 1958, and a successful Vanguard launch in the following month, this country moved step by step from the modest-sized Redstone to the intermediate range missiles, the Jupiter and the Thor, before applying any ICBM's to orbital flights. Its small, solid-fuel Scout, like Vanguard, was not evolved from a military missile.

By contrast, the Soviet Union from the outset took its original ICBM and applied it to space work for the flights from 1957 on, and still uses this vehicle, although now with improved final stage or stages. Only after some years did the Soviet Union move down in size to use of medium-range and intermediate-range missiles as first stages for space launch vehicles. Also, an improved Soviet ICBM has been brought into the stable of space launch vehicles, but until recently has been reserved exclusively for limited types of military space payloads.

When both countries needed to exceed the capability of existing military missile first stages, they moved to create launch vehicles exclusively dedicated to space launches. In this country, these were the Saturn family, plus the hybrid Titan III vehicles which combined a modified military missile with large solid-fuel strap-on boosters. In the Soviet Union, the first larger vehicle was the Proton or "D" family, and, some believe, a new larger vehicle in the Saturn V class, the "G" family, which still has not yet flown successfully, is under development. The United States has carried out a series of landing tests of the reusable winged orbiter for its Space Transportation System (STS) leading to the successful orbital test flights of 1981. It was reported that the Soviet Union has also carried out drop-tests of a reusable delta-winged manned space vehicle from a Tupolev Tu-95 Bear bomber.[24] However, there has been no positive evidence of such a vehicle having been tested in Earth's atmosphere to date.

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[24] Covault, C. Soviets Build Reusable Shuttle. Aviation Week & Space Technology, vol. 108, No. 12, pp. 14-15, Mar. 20, 1978, and Soviets Developing Fly-Back Launcher, vol. 109, No. 19, pp. 19-20, Nov. 6, 1978.

TABLE 15.—WORLDWIDE RECORD OF LAUNCHES TO EARTH ORBIT AND ESCAPE BY BASIC FIRST STAGE AND BY YEAR

Launch vehicle	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total
"A" (Sapwood) U.S.S.R.	2	1	3	3	6	13	13	22	33	34	36	41	43	43	40	47	53	49	58	54	54	59	60	54	821
Thor U.S.A.			6	14	18	35	25	29	31	22	28	19	21	16	13	11	6	9	13	11	10	11	4	3	355
"C" (Skean) U.S.S.R.								1	6		4	6	6	10	19	13	15	17	18	28	28	21	18	16	226
Atlas U.S.A.		1		1	8	14	9	16	14	32	14	7	5	2	4	6	4	2	3	4	6	14	4	7	177
"B" (Sandal) U.S.S.R.						7	4	7	7	7	13	16	14	18	12	12	10	6	5	4	2				144
Titan U.S.A.								2	10	10	9	10	8	7	8	7	8	7	9	9	7	6	5	3	125
"F" (Scarp) U.S.S.R.										2	11	7	3	6	6	1	1	3	4	8	10	3	3	14	82
Scout Algol U.S.A.					2	3	4	7	5	8	6	5	2	3	5	5	1	6	2	2	1	1	3		71
"D" (Proton) U.S.S.R.									2	1	2	4	4	4	6	1	7	6	4	5	4	5	6	5	66
Saturn I U.S.A.								3	3	1		2					3		1						13
Saturn V U.S.A.											1	2	4	1	2	2	1								13
Mu Japan															2	1		1	1		1	2	1	1	10
FB-1 China																			3	2		1			6
N (Thor) Japan																			1	1	1	1	1	1	6
Diamant B Amethyste France														2	1				3						6
Redstone U.S.A.		3									1														4
Jupiter U.S.A.			2	1	1																				4
Diamant Emeraude France									[illegible]	[illegible]	2														4
Vanguard Viking U.S.A.		1	2																						3
Long March 1 China														1	1										2
Lambda Japan														1											1
Black Arrow U.K.															1										1
Ariane L-140 ESA																							1		1
SLV-3 India																								1	1
Total	2	6	13	19	35	72	55	87	112	118	127	119	110	114	120	106	109	106	125	128	124	124	106	105	2,142

See notes pp. 58–59.

NOTES

1. This table is a count of launches which reached Earth orbit or flew to lunar distances or beyond to enter solar orbit. The total counts match other tables of this study, and match the COSPAR numbers as described in Table 14.

2. There are many variants of launch vehicles, partly through hardware improvements, and partly by combining different vehicle stages to create various total launch systems. This table has been simplified to tabulate flights grouped by the basic first stage rocket alone, without reference to the upper stages, or the use of various strap-ons to increase lift capacity.

3. Only a few Soviet launch vehicles are identified either by description or by photograph. They have been inferred to a reasonably high degree of confidence by analogy from known flights, and the repetitive use of certain launch inclinations. Apparently a common feature of Soviet launch procedures is to use a launch guidance technique that calls for the vehicle early in its flight to pass over a certain checkpoint. Launch vehicles usually have specialized launch pads. Hence a launch of one vehicle aimed to pass over a fixed checkpoint will impart an inclination to the payload orbit which is slightly different from that of a different launch vehicle from another nearby pad aimed to send that vehicle over the same fixed checkpoint. Hence at Plesetsk, an "A" vehicle may attain a flight at 81.3 degrees inclination; a "B" vehicle at 82 degrees, a "C" vehicle at 83 degrees, and an "F" vehicle at 82.4 degrees.

4. The "A" vehicle first stage also served as the original Soviet ICBM, the SS-6 Sapwood. It now carries several upper stage combinations. The Thor was originally a U.S. IRBM, and now may carry Delta or Agena upper stages, as well as lesser stages. The "C" vehicle first stage is the SS-5 Skean IRBM. The Atlas was the first U.S. ICBM, and was used without added stages for the Mercury flights, and with Agena, Centaur, or other upper stages for other orbital and escape flights. The "B" vehicle first stage was the Soviet SS-4 Sandal MRBM. The Titan used for spaceflight is derived from the Titan II ICBM, and was used for Gemini, or with Agena and other upper stages, and also with solid strap-ons, for orbital and escape missions. The "F" vehicle first stage is that used for the SS-9 Scarp, and has various upper stage combinations on it for orbital missions. The Scout is an all-solid stages orbital or probe vehicle not directly derived from a military missile, but its Algol first stage was called Aerojet Senior, using a motor originally intended for an early version of the Polaris SLBM. The "D" vehicle may not have had a direct missile origin; it first was used for orbiting the Proton payloads, and subsequently has been given added stages for a variety of missions. The Saturn I first stage was not designed as a missile, but its engines were used in the Atlas, and its clustered tanks matched the diameters of the Jupiter and Redstone missiles. The Saturn V also did not have a missile background, and it was originally developed explicitly for the Apollo lunar program. The Japanese Mu rocket is a solid fueled rocket developed by the University of Tokyo, and has had several upper stage combinations.

The FB-1, related to the CSS-X4 may also be the Long March 2, and later with a high energy upper stage will become the Long March 3. The N rocket is a Japanese derivative of the Thor rocket built under license in Japan. Several upper stage combinations have been used or will be used, and also there are various booster strapons under development.

The Diamant B was an improved rocket whose first stage was called an Amethyste L-17. The Redstone was first an American missile followon to the German V-2 (A-4), and was used with lengthened tanks for the suborbital Mercury flights, and with extra stages for orbital flights. It was also used by Australia for its Sparta stage orbital flight. The Jupiter first stage was an IRBM, and was given extra stages for orbital and escape flights. The Diamant first stage was Eméraude L-13, probably originally intended for the Force de Frappe missile, until the latter switched to solid fuels. The Vanguard was a nonmissile system derived from the Navy Viking sounding rocket, although the first stage motor came from the Hermes developmental missile system. The Chinese Long March 1 is an IRBM with added upper stages, and shows an ancestral link with the Soviet SS-3 Shyster. The Lambda was a University of Tokyo sounding rocket which with extra stages was turned into an orbital vehicle. The Black Arrow was a British launcher, successor to the Black Knight ballistics test vehicle.

The Ariane uses as a first stage a French L-140 rocket, the outgrowth of an evolving design well beyond the Amethyste stage mentioned above. The SLV-3 Indian rocket is a small solid propellant rocket, the outgrowth of a series of sounding rockets.

SOURCES.—The number of flights matches the number given COSPAR designators, and the totals carried in other tables of this study. The designation of launch vehicles has been found partly from press announcements, and often by analytical techniques described in the notes above. See appendix III of this study and also reports of the House Committee on Science and Technology, U.S. Civil Space Activities, and Worldwide Space Activities.

Table 15 (p. 56) summarizes the successful flights of basic classes of launch vehicles over the years by all countries, providing a perspective on their relative frequency of use. This table has deliberately been kept simple, and it does not reflect the great number of upper stages used with the basic vehicles.

The table shows that the Soviet original ICBM, Sapwood, or "A" remains the most used launch vehicle in the world, followed by the U.S. Thor. Use of the Sandal or "B" began in 1962 and continued through mid-1977, when it was phased out. The Skean or "C" came into use in 1964. The Scarp or "F" after its introduction in 1966 seems to have peaked early and was used only occasionally until 1980 when it was used for almost one-sixth of the Soviet launches. The Proton or "D" as a bigger vehicle is used less frequently, but its applications are growing. A first successful flight of the "G" very large vehicle is being awaited, so it does not appear in this table. Aviation Week and other publications claim there have been three flight failures of the "G" vehicle since a first attempt in 1969. Even the "D" vehicle seems to have had many troubles in development.[25]

If current plans materialize the European Space Agency's Ariane, a new entrant in the table, will make steady progress up the table together with the STS, overtaking the Saturns by 1983.

SOVIET BALLISTIC MISSILES

The Soviet Union does not name or even identify by appearance and capacity many of its launch vehicles, giving reasons of military security, although internal Soviet missile designations revealed at the SALT-II talks have been published.[26] Only after many years have pictures of some been released or models put on display. It is a satisfaction that these pictures and models when made available are consistent with the previously derived inferential analyses based upon the performance of these vehicles and the few facts disclosed by the Soviet Government.

The original Soviet ICBM which was brought into both missile and space use in 1957 was put on public display in 1967 under the label Vostok. The same launch vehicle but with a longer upper stage is used for Soyuz. Neither label is sufficiently descriptive for the purposes of this study, as this original first stage and the two kinds of upper stages are used for many different missions. Likewise, the smallest of the Soviet space orbital launchers is now on display labeled Kosmos. This is not sufficiently descriptive either because the Kosmos name has been applied to payloads launched by all five basic first stages. It may be worth emphasizing that in the absence of any comprehensive and consistent public use by the Soviet Government of a nomenclature system, all those in general use in the West have been invented in the West. In the early days of orbital flight a great variety of names of space vehicles purportedly of Soviet origin appeared in magazines, but they seem to have had no more basis than the fanciful track up the mountainside for the winged launchers which in fact never existed.

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[25] Alsop, Stewart. Salt and Apollo 13. New York, Newsweek, Apr. 27, 1970, p. 112. He described a large number of failures of this vehicle.

[26] Aviation Week and Space Technology, No. 26, June 25, 1979, p. 21.

Gradually over a period of years, Soviet missiles of the surface-to-surface type were assigned numbers with the prefix SS by the U.S. military services, and as these missiles were better and better defined, their designators and approximate characteristics were made available to the trade press or showed up in congressional testimony and designated SS-4, SS-5, SS-6, etc. Some of these missiles such as the SS-7 and SS-11 achieved a prominent place in the Soviet arsenal without being clearly seen by the Western public, and they were not used as space launchers. When missiles were seen to the extent their configurations were recognizable by the military branches of the NATO powers, code names such as Sandal, Skean, Sapwood . . . were assigned, and these also in time reached the trade press. Military authorities in the West also have created a nomenclature system for space launch vehicles, whether of military missile or other origin, carrying the prefix SL. Some years ago, in the absence of anything better in the open literature, Sheldon devised a system which is being used in this report because its use has spread throughout much of the Western world, and it meets at least minimum needs.[27]

The basic scheme is to assign a capital letter to each basic first stage, and then to use a number for the principal upper stage of the particular launch vehicle, and a second number if the earlier upper stage is replaced. A final stage is indicated by a small letter generally indicative of its capability such as e—escape, m—maneuvering, r—reentry, and h—higher performance. When discussing the appearance of a new launch vehicle from Plesetsk, now known to be F-2, Sheldon indicated that he would call the next completely new vehicle "J," having used "h" as a suffix even if tentatively, and later been less sure of the "h" classification in the absence of proof of the use of high energy fuels, which was his original speculation.[28]

Figure 6 shows the Soviet stable of launch vehicles together with the corresponding alphanumeric designation. It must be emphasized that the representations of the variants of the D and F vehicles are to some extent speculative.

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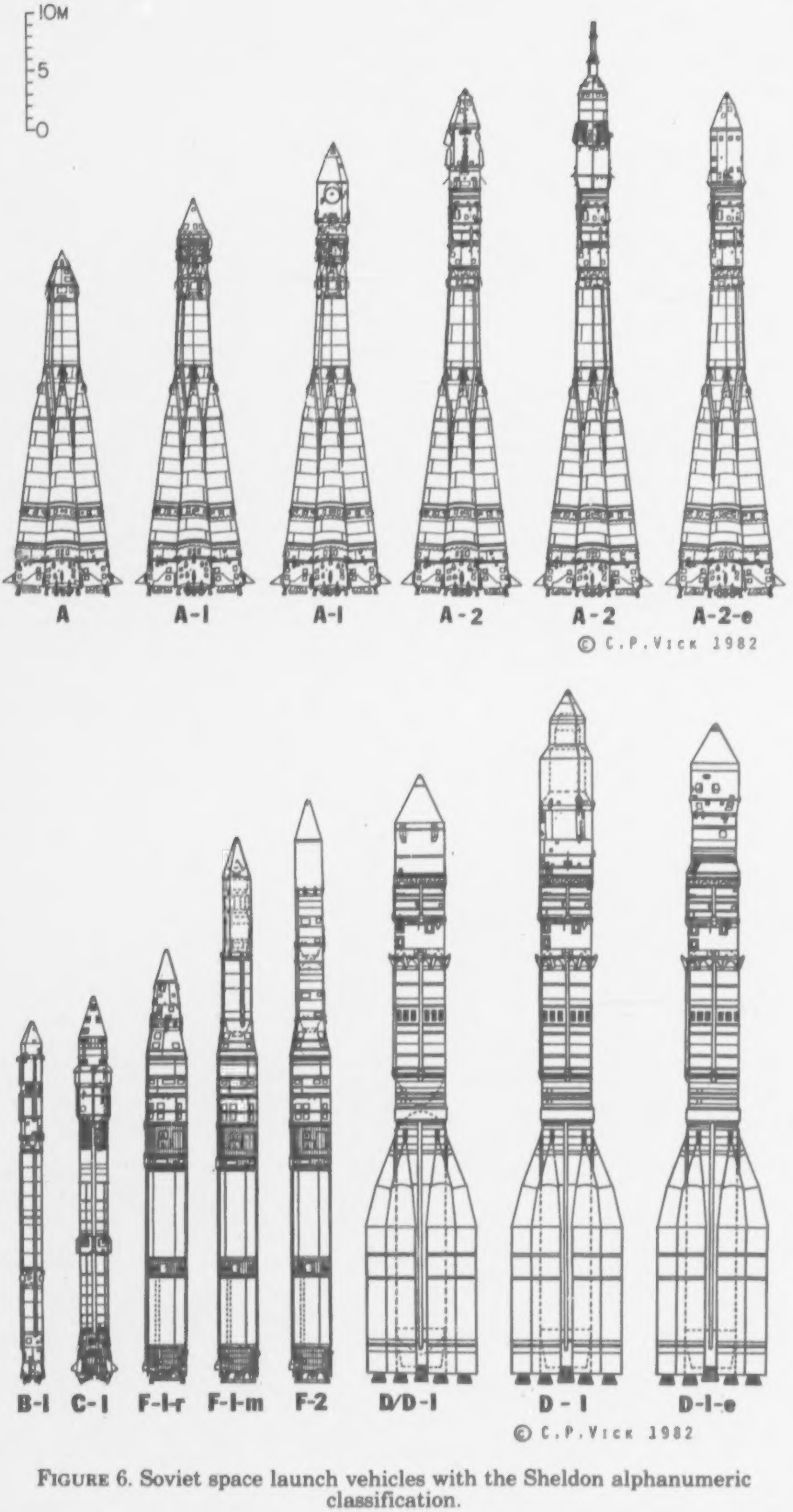
[27] Sheldon, C. S. The Soviet Space Program: A Growing Enterprise, TRW Space Log, vol. 8, No. 4, pp. 2-23, Winter 1968-69.

[28] Sheldon, C. S., private communication to G. E. Perry, Jan. 12, 1979.


10M
5
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A-1
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A-2
A-2-e
© C.P.Vick 1982
B-1
C-1
F-1-r
F-1-m
F-2
D/D-1
D-1
D-1-e
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FIGURE 6. Soviet space launch vehicles with the Sheldon alphanumeric classification.

Table 16 is a listing of the major Soviet surface-to-surface ballistic missiles in the U.S. Department of Defense SS-number order along with NATO code names where known giving details of propulsion, launch and guidance modes, dimensions and capabilities.

TABLE 16.—SOVIET SURFACE-TO-SURFACE MAJOR BALLISTIC MISSILES

U.S. DOD No.	NATO name	Soviet No.	Stages	Propulsion	Launch mode	Guidance mode	Length	Diameter	Launch weight	Range	Initial operations
SS-1A	Scunner[1]	A-1	1	Liquid	Mobile	Programed					
SS-1B	Scud A	A-4	1	do	do	Radio	10.5	0.85	4,500	150	1957
SS-1C	Scud B		1	do	do	Inertial	11.2	.85	6,300	280	1965
SS-2	Sibling	A-2	1		do						
SS-3	Shyster	A-3 (V-5-V)	1	do		Radio	21	1.6	26,000	1,200	
SS-4	Sandal		1	do	Surface	do	21	1.6	27,000	1,800	1958
SS-5	Skean		1	do	Silo	Inertial	25	2.4		3,500	1961
SS-6	Sapwood		1½	do	Surface	Radio	31	10.3		8,000+	1958
SS-7	Saddler		2	do	Silo	Inertial	35	3.0		11,000	1962
SS-8	Sasin		2	Stor liq	do	do	25	2.75		10,000	1963
SS-9	Scarp		3	do	do	do	35	3.0		12,000	1967
SS-10	Scrag		3	Liquid	do	do	39	2.75		8,000+	Canceled
SS-11	Sego		2	Stor. liq	do	do	20	2.5		10,000	1966
SS-12	Scaleboard		1	do	Mobile	do	11			800	1969
SS-13	Savage		3	Solid	Silo	do	20	1.7		10,000	1969
SS-14	Scapegoat in Scamp		2	do	Mobile	do	10.6	1.4	12,000	4,000	
SS-15	? in Scrooge		?		do	do	19	1.7		5,000+	
SS-16		RS-14	3	Solid	Silo	do	20	2.5	36,000	9,200	1978
SS-17		RS-16	2	Stor. liq	Silo—cold	do	24	2.5	65,000	11,000	1975
SS-18		RS-20	2	do	do	do	35	3.0	220,000	16,000	1974
SS-19		RS-18	2	do	Silo	do	25	2.75	78,000	10,100	1974
SS-20			1	Solid	Mobile	do	16	1.7	25,000	4,400	1977
SS-21			1	do	do	do				120	
SS-22			1	do	do	do				800	
SS-23			1	do	do	do				200	
SS-				do	Silo	do					198-
SS-				do	do	do					198-
SS-				Stor. liq	do	do					198-
SS-				do	do	do					198-

TABLE 16.—SOVIET SURFACE-TO-SURFACE MAJOR BALLISTIC MISSILES—Continued

U.S. DOD No.	NATO name	Soviet No.	Stages	Propulsion	Launch mode	Guidance mode	Length	Diameter	Launch weight	Range	Initial operations
SS-N-4	Sark			?	Submarine	?	15	1.9		650	1958
SS-N-5	Serb		2	Stor. liq	do	Inertial	12.9	1.42	18,000	1,200	1963
SS-N-6	Sawfly		2	do	do	do	9.65	1.65	19,000	3,000	1968
SS-N-8			2	do	do	do	1.95	1.65	20,000	7,800	1973
SS-N-17			2	Solid	do	do	11.06	1.65		5,000+	
SS-N-18		RSM-50	2	?	do	do	14	1.8		7,700	1979

[1] Capability—V-2 of German origin.
See notes p. 65.

NOTES

1. Although this study is not concerned with missile capabilities, so many launch vehicles used for space are derived from missiles that a brief review of missiles is a step toward understanding the launch vehicles.

2. This table should be used with care, because available sources differ sufficiently in dimensions and capabilities that they can only be taken as indicative of directions, not definitive truth.

3. The missiles listed include as many of the U.S. assigned designators as possible, both for land-based surface-to-surface missiles and sea-based surface-to-surface missiles, both of the ballistic type. No numbers have been assigned yet to the fifth generation missiles under current development.

4. Only a few Soviet designators have become known through SALT negotiations.

5. NATO code names are not complete, either.

6. The label "liquid" refers to missiles at least one of whose stages uses cryogenics (liquid oxygen), while "storable liquid" refers to those that have the added flexibility of not employing cryogenics.

7. It will be noted that some missiles are relatively mobile, others were surface launched, and most larger current missiles are either silo or submarine launched.

8. While the first missile was clockwork programed like the V-2, systems progressed from radio guided to inertial guidance, with both types of guidance found in some missiles during the transition.

9. Sources differ not only as to dimensions, weight, range, but also as to what year many of the missiles reached operational status (IOC). Numbers should be within 10 percent of accurate.

10. Although some missiles have been paraded in Moscow or shown up in official Soviet photographs, the U.S.S.R. has never provided an official comprehensive list, and has not even provided clear pictures of what were the two most ubiquitous missiles, the SS-7 and the SS-11. Their shapes are best known from models displayed by the U.S. Department of Defense.

SOURCES.—Data have been published in tables in Jane's All the World's Missile Systems, and in annual review issues of Aviation Week, Flight International, Air Force, and Interavia. Data used to appear in the now defunct magazine, The Aeroplane. A few dimensions have been scaled from silhouettes appearing in posture statements of the U.S. Department of Defense.

SOVIET ROCKET ENGINES

Even though the Soviet Union has not disclosed an overall nomenclature system for its launching vehicles, it has identified some of the individual rocket engines, such as the RD-107, RD-108, RD-119, etc. Some of these have been displayed in Soviet exhibitions outside the Soviet Union and are on permanent display, with placards giving their characteristics, in the Moscow Museum of Industry. In addition, a rocket engine museum is maintained in the Ionnovskiy ravelin of the Petropavlovsk Fortress in Leningrad where historic engines of the Gas Dynamics Laboratory Experimental Design Bureau (GDL-OKB) are on display. The chief designer of the GDL-OKB, Academician Valentin P. Glushko, has been a principal source of information about Soviet rocket engines. On the occasion of the 50th anniversary of the foundation of the GDL he produced a booklet on the development of rocketry and space technology in the Soviet Union giving some details of performance and pictures of the RD-107, RD-119, and RD-214 engines.[29] A second booklet, in 1975, gave more details and also showed pictures of the RD-219 and RD-108 engines.[30] Expected for the last year or so, but not available as of December 31, 1981 is a new encyclopedia with fresh disclosures by Glushko. Glushko has always alluded to there being newer developments he has not been allowed to write about. Apparently Kosberg and Isayev (the latter now deceased) have not published about their engines, and Glushko has only alluded to their work without specifying performances.

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[29] Glushko, V. P. Development of Rocketry and Space Technology in the U.S.S.R., Novosti, Moscow, 1973.

[30] Glushko, V. P. Rocket Engines GDL-OKB, Novosti, Moscow, 1975.

Details were given for the RD-216 and RD-253 engines in 1976 in a NASA Technical Translation of Liquid Rocket Space Engines, by Bychkov, Nazarov and Prischepa.[31]

Table 17 summarizes the data available on Soviet space-related rocket engines.

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[31] Bychkov, V. N., G. A. Nazarov and V. I. Prischepa, NASA Technical Translation, NASA TT F-17503, Washington, D.C.

TABLE 17.—SOVIET SPACE-RELATED ROCKET ENGINES

Soviet designator	Design bureau chief	Chambers/ engine (main, verniers)	Pressure in atmospheres	I_{sp} seconds (vacuum)	Fuel	Oxidizer	Total thrust each in metric tons	Duration of burn (SEC)	Where applied	What stage	Number in stage	First use in listed vehicle
RD-100	Glushko	1		234	Alcohol	Lox	30		V-2	1st	1	1948
RD-101	do	1	26	238	do	do	43		V-2A	1st	1	1949
RD-103	do	1	28	245	do	do	55		V-5-V	1st	1	1953
RD-107	do	4+2	60	314	Kerosene	do	102	180	A-1, A-2	Strap-ons	4	1957
RD-108	do	4+4	52	315	do	do	96	300	A-1, A-2	Sustainer	1	1957
RD-110	do						120		None			(1951)
RD-111	do	2	80	317	do	do	166		SS-10?	1st	2	1962
RD-119	do	1+8	80	352	UDMH	do	11		B-1	2d	1	1962
RD-214	do	4	45	264	Kerosene	Nitric acid	74		B-1	1st	1	1962
RD-216	do	2	68	284	UDMH	N_2O_4	38		C-1	1st	2	1964
RD-219	do	2	75	293	do	Nitric acid	90		F-1?	2d	1	1966
									SS-10?	2d	1	1962?
RD-253	do	1	150	315?	do	N_2O_4	250?		D-1	Strap-ons	6	1965
									G-1?	1st	24-36	1969
RD-	Kosberg	1+4		250?	Kerosene	Lox	5		A-1	2d	1	1959
RD-	do	4+4		282?	do	do	30	230	A-2	2d	1	1960
RD-	do	1		340	UDMH	N_2O_4	30		C-1	2d	1	1964
RD-	do			325	do	N_2O_5	300?		D-1	Sustainer	1	1965
RD-	do			340	do	N_2O_4	60?		D-1	2d	1	1965
RD-	do	6+4			do	do			F-1, F-2	1st	1	1966
RD-	Isayev	1		305?		Nitric acid	6.35	250	A-2-e	3d	1	1960
RD-	do?			350	do	N_2O_4	15.5		D-1-e	3d	1	1967
TDU-1	do	1	57		Amine	N_2O_4	1.614	25	Vostok		1	1960
ODU	do	1		290?	UDMH	Nitric acid	.3		Salyut 6		2	1977
KDTU-1	do	1	64				4.64	50	Luna 4-14		1	1963

TABLE 17.—SOVIET SPACE-RELATED ROCKET ENGINES—Continued

Soviet designator	Design bureau chief	Chambers/engine (main, verniers)	Pressure in atmospheres	I_{sp} seconds (vacuum)	Fuel	Oxidizer	Total thrust each in metric tons	Duration of burn (SEC)	Where applied	What stage	Number in stage	First use in listed vehicle
	Isayer	1			UDMH	N_2O_4	.75–1.93	650	Luna 15–24	(High)	1	1969
	do	2			do	do	.21–.35	30	Luna 15–24	(Low)	1	1969
	do	1	94		do	do	1.92		Luna 16	(Moon launch)	1	1970
	do	1	12		do	do	.2		Venera 1–8		1	1960
									Molniya			
	do		95				1.0–1.9		Mars 2–7		1	1971
									Venera 9–12			
	do	1	40		do	do	.415		Soyuz	Main	1	1967
	do	1			do	do	.2		Soyuz	Backup	2	1967

See notes p. 69.

NOTES

The Soviets have developed many of their engines by clustering a number of chambers and verniers, all fed by a single pump. The "chambers/engine" column provides this additional data. For example, the RD-119 has a single main chamber plus four fixed large verniers for pitch and yaw control plus four smaller verniers for roll control. Hence, "1+8"; one main and eight verniers.

The duration of burn data are from typical mission profiles. For example, the Luna 9-14 series performed a small translunar correction plus a 48 second retro for a soft lunar landing, for a total of about 50 seconds. The Luna 15-24 descent stage high thrust engine can run for 650 seconds at the lower end of its thrust range. Its low thrust engine, used briefly just before touch down to minimize soil disturbance, can run for 30 seconds at the lower end of its thrust range. The A-2-e duration of burn is based on Venera missions, which appear to have carried a full propellant load. The Molniya and Luna missions may have carried less than a full load, using the savings to increase total payload.

The following staging convention has been adapted for this table. The A-class booster uses four strap-on boosters attached to a sustainer core stage. The D-class uses six strap-on boosters around its sustainer. Therefore, the stages from bottom to top are: strap-ons, sustainer, 2, and 3. Stage 3, when used, is the escape stage used on deep space missions to synchronous orbit, the Moon or planets.

The Venera 2-8 spacecraft engine was also used for Mars-1, as well as the current Molniya series. The Venera 9-14 spacecraft engine was also used on the Mars 2-7 missions. The Luna soil sample return missions (16, 18, 20, 23, 24) each carried lunar ascent stages. The Luna-17 and -21 missions carried rover vehicles in place of ascent stages. The Luna-19 and -22 missions were orbiters only, and carried what appear to be rover shells, in place of ascent stages, to carry their mission payloads.

SOURCES.—See particularly Glushko, V. P., Raketneyye dvigatelli GDL-OKB, Moscow: Novosti Press, 1975, and Bychkov, V. N., G. A. Nazarov, and V. I. Prishchepa, Kosmicheskiye zhidkostno-raketnyye dvigateli in Novoye v zhizni nauke, teknike, Seriya "Kosmonavtika astronomiya," No. 9, 1976, pp. 1-64.

UPPER STAGES

These are the stages which go into orbit along with the payload(s) from each launch. The Royal Aircraft Establishment, Farnborough, has gradually evolved its interpretation of these objects over the years. Their estimates are based upon study of photographs and published Soviet data, radar and optical signatures, decay rates, and performance studies made by Western analysts. Table 18 summarizes the standard upper stages found in orbit in connection with each of the known classes of Soviet launch vehicles.

TABLE 18.—SUMMARY OF UPPER STAGES IN ORBIT AS IDENTIFIED BY THE ROYAL AIRCRAFT ESTABLISHMENT

Launch vehicle	SL	Stage	Length	Diameter	Empty weight	Typical payloads or missions
A	SL-1-2	Core	28.0	2.95	4,000	Sputnik 1-3.
A-1	SL-3	Luna	3.7	2.6	1,100	Luna 1-3.
A-1	SL-3	......do	3.8	2.6	1,440	Korabl Sputnik, Vostok, Elektron, Kosmos Recon, Meteor Kosmos elint.
A-m		Maneuverable with payload.	2.0	1	600	Polet 1-2.
A-1-m		Luna				(Suborbital.)
		Maneuverable with payload.	10.0	2	4,000	Kosmos 102, 125.
A-2	SL-4	Venera	7.5	2.6	2,500	Voskhod, Soyuz, Kosmos Recon.
		Maneuvering unit	1.5	2	600	Kosmos Recon.
A-2-e	SL-6	Venera	7.5	2.6	2,500	Luna 4-14, Venera 1-8, Mars 1, Molniya, Prognoz.

TABLE 18.—SUMMARY OF UPPER STAGES IN ORBIT AS IDENTIFIED BY THE ROYAL AIRCRAFT ESTABLISHMENT—Continued

Launch vehicle	SL	Stage	Length	Diameter	Empty weight	Typical payloads or missions
		Escape	2.0	2	440	Luna 4–14, Venera 1–8, Mars 1, Molniya, Prognoz.
A–2–m	SL–5	Venera	7.5	2.6	2,500	
		Maneuverable with payload.	?	?	?	Kosmos 379, 398, 434.
B–1	SL–7	Upper	8.0	1.65	1,500	Kosmos science, radar calibration, Interkosmos 1–9.
C–1	SL–8	do	7.4	2.4	2,200	Kosmos navigation, elint, tactical communication, radar calibration, ASAT target, geodesy, Interkosmos 10–20.
D–1	SL–9	Proton	12.0	4	4,000	Proton 1–4, Salyut 1–6, Kosmos 557 (Kosmos 929?).
	SL–10					
D–1–e	SL–12	do	12.0	4	4,000	Kosmos 146, 154, Luna 15–24, Zond 4–8, Venera 9–12, Mars 2–7.
D–1–h	SL–13	Escape	3.9	3.9	1,900	Raduga, Gorizont, Ekran.
		Apogee	2.0	2	440	Raduga, Gorizont, Ekran, Kosmos early warning.
D–1–m		Proton	12.0	4	4,000	
		Maneuverable with payload.	?	?	?	Kosmos 382.
F–1–r	SL–11A	Upper	8.0	2.5	1,500	
		Reentry with payload	2.0	1	?	Kosmos FOBS.
F–1–m	SL–11B	Upper	8.0	2.5	1,500	
		Maneuverable with payload.	4.0	2	?	Kosmos ASAT.
F–1–m		Upper	8.0	2.5	1,500	
		Maneuverable with payload.	6.0	2	?	Kosmos ocean surveillance.
F–2		Upper				Kosmos ocean and Earth resources. Not recognized by RAE, as a new type launch vehicle.

NOTES

1. In the absense of definitive information from the U.S.S.R., these estimates are an excellent starting place. In several instances, analysts may not accept the RAE figures as the most probable. For example, the empty weight of the core sustainer stage of the A class vehicle as placed in orbit with Sputnik 1, 2, and 3 may have been closer to 6,000 kilograms rather than 4,000.

2. By linking the data in table 16 on Soviet missiles with the data of this table, two pieces of the larger puzzle of incomplete information on Soviet launch vehicle characteristics are provided, to join such other pieces as have been supplied in the occasional papers and books by V. P. Glushko, the chief designer of the GDL which has supplied many of the rocket engines used in Soviet missiles and space launch vehicles. A summary of what is known about Soviet rocket motors related to space is provided in table 17.

SOURCES.—Royal Aircraft Establishment, Farnborough, Hants, England: Table of Earth Satellites (various years) and Table of Space Vehicles (various years) spaceflight. vol. 23, April 4, 1981, p. 120.

LAUNCH VEHICLES

Table 19 is a summary of the characteristics of Soviet launch vehicles. Because of Soviet secrecy, it must be considered as highly provisional. This is especially true when irreconcilable differences exist in partial Soviet data made public, and when Western observers have not seen pictures of some models and disagree as to their possible performance.

David R. Woods, in correspondence with Sheldon in January 1976, made estimates of the dimensions of the C-1 which differ only slightly from those of the table. Additional calculations by Phillip S. Clark (some of whose analyses have been published in Spaceflight and are cited in the relevant sections later in this chapter) to appear in a book not yet in print, have been made available to Sheldon to make this table more complete. Clark has also developed a more elaborate nomenclature system to describe launch vehicle variants than that used here. His overview of Soviet launch vehicles appeared in the February 1982 issue of the Journal of the British Inteplanetary Society.[32] With this warning about uncertainties, perhaps the table at least gives some notion of the scope of launch vehicles, the relatively modest number of kinds, and about what their dimensions, powerplants, fuels, and thrust approximate.

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[32] Clark, P. S. Soviet Launch Vehicles: An Overview, J. Brit, Interplan. Soc., vol. 35, No. 2, Feb. 1982, pp. 51–58.

TABLE 19.—SOVIET SPACE LAUNCH VEHICLES

Vehicle and stages	Length	Diameter	Main engines	Total chambers	Engine designators	Total thrust	Lift capacity to 200 km	First orbital flight	Typical payloads
A									
Core sustainer	28	2.95	1	4	RD–108	96	2,000	1957	Sputnik 1–3.
Four booster strap-ons	19	3	4	16	RD–107	408			
Shroud	3.87	10.3							
Overall	31.87	10.3	5	20		504			
A–1									
Core sustainer	28	2.95	1	4	RD–108	96	5,000	1959	Luna 1–3.
Four booster strap-ons	19	3	4	16	RD–107	408			
Luna stage	3.1	2.58	1	1	RD–	5			
Shroud	2.58	2.58							
Overall	33.68	10.3	6	21		509			
A–1									
Core sustainer	28	2.95	1	4	RD–108	96	5,000	1960	Korabl Sputnik, Vostok, Elektron, Meteor Kosmos (elint ferret, weather and recon.)
Four booster strap-ons	19	3	4	16	RD–107	408			
Luna stage	3.1	2.58	1	1	RD–	5			
Shroud	6.9	2.84							
Overall	38	10.3	6	21		509			
A–2									
Core sustainer	28	2.95	1	4	RD–108	96	7,500	1963	Voskhod, Kosmos (precursors, recon.)
Four booster strap-ons	19	3	4	16	RD–107	408			
Venera stage	8	2.58	1	4	RD–	30			
Shroud	6.9	2.84							
Overall	42.9	10.3	6	24		534			
A–2									
Core sustainer	28	2.95	1	4	RD–108	96	7,500	1967	Soyuz, Kosmos precursors.
Four booster strap-ons	19	3	4	16	RD–107	408			
Venera stage	8	2.58	1	4	RD–	30			
Shroud	13.3	3.04							
Overall	49.3	10.3	6	24		534			

A-2-e									
Core sustainer	28	2.95	1	4	RD-108	96	7,500	1961	Venera 1-8, Zond 1-3, Mars 1, Molniya, Prognoz, Luna 4-14, Kosmos (early warning).
Four booster strap-ons	19	3	4	16	RD-107	408			
Venera stage	8	2.58	1	4	RD-	30			
Escape stage	2	2	1	1	RD-	6.35			
Shroud	6.9	2.84							
Overall	42.9	10.3	7	25		540.35			
B-1									
First stage	20.3	1.65	1	4	RD-214	74	600	1962	Kosmos (science and calibration), Interkosmos 1-9.
Second stage	8.5	1.65	1	1	RD-119	11			
Shroud	3.3	1.65							
Overall	32.1	1.65	2	5		85			
C-1									
First stage	19.8	2.44	2	4	RD-216	176	1,500	1964	Kosmos (science, calibration, elint ferret, navigation, tactical communications, ASAT target), Oreol, Interkosmos 10-20, Ariabat, Bhaskara, Sneg.
Second stage	8.4	2.44	1	1	RD-	30			
Shroud	3.4	2.44							
Overall	31.6	2.44	3	5		206			
D-1									
Core sustainer	31.3	4.1	1		RD-253	250	22,500	1965	Proton, Salyut, Kosmos 557.
Six booster strap-ons	29.8	3.1	6		RD-253	1,500			
Second stage	22.0	4.1	1		RD-	60			
Shroud	14.0	4.1							
Overall	97.1	13	8			1,810			(Salyut.)
D-1-e									
Core sustainer	31.3	4.1	1		RD-253	250	22,500	1967	Zond 4-8, Luna 15-24, Mars 2-7, Venera 9-12, Molniya 1-S, Kosmos (early warning), Statsionar classes.
Six booster strap-ons	29.8	3.1	6		RD-253	1,500			
Second stage	22.0	4.1	1		RD-	60			
Escape stage	6.6	4.0	1		RD-	15.5			
Shroud	5.7	4.1							
Overall	95.4	13	9			1,825.5			(Luna.)
F-1-m (or -r)									
First stage	20.7	3	1	6	RD-			1966	Kosmos (FOBS, ASAT, ocean surveillance.)

TABLE 19.—SOVIET SPACE LAUNCH VEHICLES—Continued

Vehicle and stages	Length	Diameter	Main engines	Total chambers	Engine designators	Total th[illegible]	Lift capacity to 200 km	First orbital flight	Typical payloads
Second stage	9	3		2	RD-219	90	5,000		
Third stage	6	2?							
Shroud	?	?							
Overall	?	?							
F-2									
First stage	20.7	3	1	6	RD-		7,800?	1977	Kosmos (ocean and Earth resources.)
Second stage	?	3?							
Third stage	?	?							
Shroud	?	?							
Overall	?	?							
G-1-e									
First stage	42?	15?	24-36?		RD-253?	6-9,000	135,000	(1969)	Unsuccessful, but intended originally to support manned lunar landing program.
Second stage	35?	12?	6?		RD-253?	1,500			
Third stage	14?	8?	1?		RD-253?	250			
Fourth stage	10?	6?	1?		RD-	60			

See notes pp. 75-76.

NOTES

1. Dimensions are given in meters. Engine designators are Soviet. Total thrust for each stage is given in metric tons. Lift capacity to 200 kilometers is given in kilograms.

2. The table excludes attempts to describe a limited number of early experimental A class vehicles, because not enough is known about the final stage. These types may include an A-m used for Polet 1 and 2, and an A-1-m used for Kosmos 102 and 125. Possibly in the Soviet stable there should be an F-1-s or even a C-1-s which use an ion propulsion final stage to maintain orbits on certain flights.

3. This table must be used with considerable caution because in only a few instances have Soviet authorities revealed dimensions, thrusts, or lifting capacities. Western analysts working with data in the public domain are reduced to studying data on Soviet missiles, themselves not exact, studying the few released photographs of launch vehicles, and making calculations about performance from a combination of estimated tank capacities, a few known thrust figures, and known payload weights. Because analysts have not made identical assumptions, the result is a range of figures for a number of these vehicles.

4. The Soviet Union has published dimensions only for the A-1, A-2, and B-1 launch vehicles. Only a few of the engines have been described as to characteristics and work performance (see table 17).

5. The A-1 and B-1 rockets were first put on public display in 1967, although each had been flying since 1959 and 1962 respectively. The C-1 vehicle was first shown in photographs released in 1975, although it had been flying since 1964. The D-1 vehicle has not been shown in complete form, only the upper stages so far, even though it has been flying since 1965. No F-1 or F-2 vehicle has been shown at all, even though these have been flying since 1966 and 1977 respectively. No details have come from Soviet sources about the G-1.

6. The first stage of the A vehicles, both core and four liquid strap-ons is now reasonably certain from Soviet disclosures. Dimensions and thrusts of the A-1 and A-2 upper stages are known, but not the engine designators. The A-2-e escape stage can be estimated but is less well known.

7. The B-1 has been fairly completely described, although not its lifting capacity.

8. The C-1 is known imperfectly. There are still slightly different estimates of its length. The first stage engine thrust and designation is known, but not the second stage. Lifting capacity has not been announced. The few figures available on payload weights are hardly different from those of the B-1, which is not credible for a rocket whose military counterpart is of much greater power, and whose first stage thrust is also known to be more than twice as great.

9. The D-1 and D-1-e have not been adequately described, although the first stage engine has been given a Soviet designator in published records. Photographs suggest six strap-ons, and perhaps like the A class vehicle, essentially the same engine may serve both the central core and the strap-ons. There may be one difference though, in that the core may not be lit on the ground as in the A class, but started at altitude. Only Western estimates are available on the thrusts of upper stages.

10. The F class vehicles are known to be related to the SS-9 Scarp, which has six nozzles in the first stage. It is possible that the second stage is an engine described in Soviet reports as in current use which does not seem to be used in any other vehicle. It is believed that both an F-1 and an F-2 vehicle are in use, because the flight patterns are markedly different. In the F-1 series, there may be more alternate third stages than can be confirmed from open sources.

11. The G-1 or G-1-e have not been identified by the Russians at all in published reports, but facilities have been visible to visitors at Tyuratam, and a Soviet book has pictured drawings of a launch facility which permits the scaling of a large vehicle consistent with that predicted by U.S. officials which could be accommodated by these facilities. Beyond that, attempts to describe the component parts by dimensions, weights, and thrusts is largely an exercise in parametric studies, not firm prediction. It is tempting to think that adaptations of the D class vehicle might have gone into the upper stages of the G class in the interests of development economy, and that the basic engine used in the D class might be clustered in sufficient numbers to power the first stage of G.

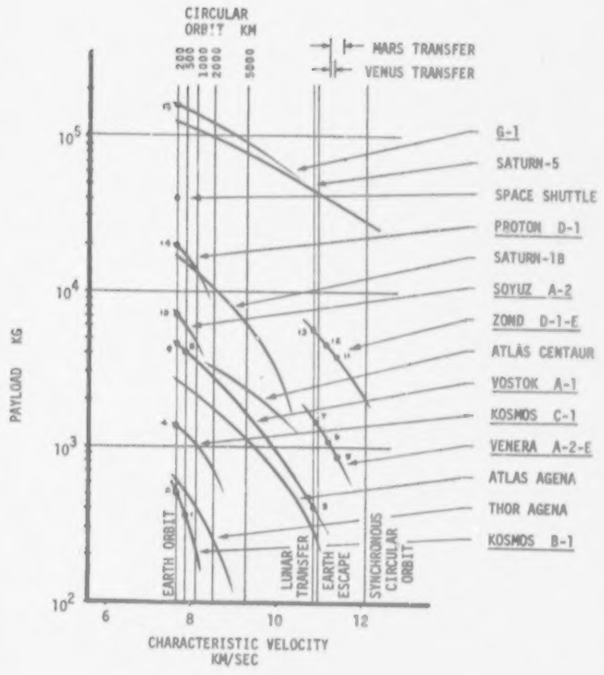
12. There are some discrepancies in Soviet explanations of even the A vehicle which are not easily cleared up. The A-1 vehicle was described as having a first stage thrust of 600 tons. Through a clue provided by a Soviet engineer in a private discussion, it was explained that by adding together the thrust of the core vehicle plus the four strap-ons, and then adding in the same core vehicle by itself, one could come out with the 600 ton thrust mentioned. Also, adding the core, four strap-ons,

and second stage matched the 6 engines referred to in the Soviet claim. But the same Soviet sources said the A-2 vehicle had a thrust of 650 tons and 7 engines. No double adding seems to yield the necessary 650 tons, although there is a more powerful second stage on the A-2. Nor is it possible to find 7 engines instead of 6 on the A-2. A slight possiblity would be that the second stage engine with 4 nozzles is really 2 engines of 2 nozzles each, but this is contradicted by Soviet source materials.

SOURCES.—See particularly Aviatsiya i Kosmonavtika No. 11, 1967, pp. 34-35, and ibid. No. 12, 1967, pp. 33-37; also, Vestnik, Akademii Nauk, No. 11, 1967; and the book by A. A. Blagonravov, et al.: U.S.S.R. Achievements in Space Research (First Decade in Space, 1957-67), published by Nauka, Moscow, 1968, 557 pp. The photographs or drawings have appeared over a period of years in Aviation Week, Interavia, Flight International, the New Scientist, Spaceflight, Space World, and in Norman L. Baker: Soviet Space Log 1957-67, Space Publications, Inc., Washington, D.C., 59 pp. Also see drawings by G. Harry Stine in Analog and American Aircraft Modeler, and in Bjorn Bergqvist, Vostoks Barfarkost, Teknist Tisskrift (Swedish), 1968 H2, and other drawings by Maarten Houtman in Spaceview, Amsterdam, and Peter Smolders in Dutch and English publications. More recent detailed dimensions of the A-2 appeared in the Soviet press kit for the Apollo-Soyuz mission in 1975. Articles by Phillip S. Clark: The Proton Launch Vehicle, Spaceflight, September 1977; The Skean Program, Spaceflight, August 1978; The Sandal Program, Spaceflight, January 1981, and The Scarp Program, Spaceflight, May 1981.

LIFTING CAPACITIES

Table 20 summarizes data for each known rocket type as to the number of kilograms which can be sent to different orbits, and trends over the years as these vehicles have evolved. It suffers the same uncertainties as other tables where the Soviet Government released only partial information, so must be considered provisional and subject to revision. Because the Russians do not publish graphs which show the effects of changes of orbital altitude or orbital inclination on the carrying capacity of their launch vehicles, Sheldon adopted the technique for developing some approximate and generalized curves which matched those for several common U.S. launch vehicles, even though there was not complete uniformity, depending upon the staging used by a particular vehicle. With the few data points available from Soviet sources, or best Western estimates, he applied interpolated or extrapolated generalized ratios to the limited Soviet data to fill the spaces on the chart reproduced as figure 7 and table 20. Due to the absence of any firm data points for the F vehicle no curve is shown for this vehicle in figure 7.



	DATA POINTS	KG	
1	ARYABHATA	360	
2	KOSMOS	600	
3	LUNA-3	435	
4	KOSMOS	1500	EST.
5	MARS-1	893	
6	VENERA-8	1184	
7	LUNA-11	1640	
8	METEOR	3800	
9	VOSTOK-1	4725	
10	KOSMOS	7500	
11	MARS-5	3750	EST.
12	MARS-3	4650	
13	LUNA-20	5600	EST.
14	SALYUT-1	18900	
15		160000	EST.

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FIGURE 7. Approximate performance characteristics of Soviet and American space launch vehicles.

Great caution must be exercised when making use of the chart and the table. It should be remembered that the vehicles have not flown at all the altitudes listed and that in the few cases where Soviet data is available there is no guarantee that the launch vehicle was being used to its full capability. The end result is not precision, but at least an order of magnitude approximation which will help the user have a general sense of what to expect from particular Soviet launch vehicles. These numbers in turn make it possible to estimate the upper limits for particular classes of known payloads which may fly at different inclinations or altitudes, to make sure that such estimates do not exceed the estimated lift-capacities of the launch vehicle for some of the various orbits used for that class of payload. Commenting on the draft of the table, Clark suggested that the capacity of the C-1 should be reduced by an average of 50 percent since he had initially overstated the capacity in his Spaceflight review. However, Soviet space engineers talking informally with Swedish engineers at Kapustin Yar for the launch of Intercosmos 16 indicated that, although the mass of Intercosmos 16 was only 435 kg, its C-1 launch vehicle had a payload capacity of 1,500 kg.

TABLE 20.—SOVIET LAUNCH VEHICLE LIFTING CAPABILITIES—SELECTED VEHICLE AND INCLINATIONS

Period/altitude	87/170	88/195	89/230	90/265	91/300	92/350	93/400	94/450	95/500	96/550	97/600	98/650	99/700	100/ 750	101/ 800	102/ 850	103/ 900	104/ 950	105/ 1,000	110/ 1,250	115/ 1,500
A-1—65°	4,917	4,850	4,782	4,717	4,650	4,560	4,460	4,365	4,270	4,195	4,120	4,022	3,925	3,830	3,735	3,637	3,540	3,470	3,400	2,985	2,570
A-1—81°	4,620	4,560	4,495	4,435	4,370	4,285	4,190	4,105	4,015	3,945	3,875	3,780	3,690	3,600	3,510	3,420	3,330	3,260	3,195	2,805	2,415
A-2—52°	7,250	7,150	7,055	6,960	6,860	6,720	6,580	6,435	6,290	6,185	6,080	5,935	5,790	5,645	5,500	5,360	5,220	5,110	5,000	4,395	3,790
A-2—65°	6,815	6,720	6,630	6,540	6,450	6,320	6,185	6,050	5,910	5,815	5,715	5,580	5,440	5,310	5,170	5,040	4,910	4,805	4,700	4,130	3,560
A-2—81°	6,300	6,220	6,140	6,055	5,970	5,850	5,725	5,600	5,470	5,380	5,290	5,165	5,040	4,910	4,785	4,665	4,540	4,445	4,350	3,825	3,300
B-1—49°	405	400	395	390	385	378	370	360	350	345	340	330	320	315	310	300	290	285	280	245	210
B-1—81°	352	348	343	339	335	329	322	313	305	300	296	287	278	274	270	261	252	248	244	213	183
C-1—51°	1,100	1,090	1,079	1,063	1,046	1,025	1,003	981	959	943	926	905	883	861	839	818	801	790	774	741	687
C-1—74°	1,010	1,000	990	975	960	940	920	900	880	865	850	830	810	790	770	750	735	725	710	680	630
C-1—83°	968	960	950	936	922	902	883	864	845	830	816	797	778	758	739	720	706	696	682	653	605
D-1—52°	19,500	19,200	18,900	18,600	18,400	17,650	17,400	17,150	16,900	16,600	16,300	15,925	15,550	15,175	14,800	14,400	14,000	13,720	13,440	11,810	10,180
F-1—50°	5,065	5,000	4,935	4,865	4,800	4,700	4,600	4,500	4,400	4,320	4,250	4,150	4,050	3,950	3,850	3,745	3,640	3,570	3,500	3,075	2,650
F-1—66°	4,600	4,540	4,490	4,430	4,360	4,270	4,180	4,090	4,000	3,920	3,860	3,770	3,680	3,590	3,500	3,405	3,310	3,245	3,180	2,790	2,405
F-2—76°	7,935	7,830	7,725	7,620	7,520	7,360	7,200	6,995	6,890	6,775	6,660	6,500	6,340	6,185	6,030	5,865	5,720	5,600	5,480	4,800	4,150
F-2—82°	7,695	7,620	7,520	7,420	7,320	7,135	7,010	6,845	6,700	6,590	6,480	6,320	6,170	6,020	5,870	5,720	5,570	5,450	5,330	4,670	4,040

VEHICLE AND INCLINATION

Period/distance	12 hr/ 40,000 eccen.	24 hr/ 35,860 circ.	Moon	Venus	Mars
A-1—69°			435		
A-2-e—52°			1,640	1,180	
A-2-e—65°	1,890		1,506		894
D-1-e—52°		2,880	5,600	5,033	4,650

See notes p. 79.

NOTES

1. This table must also be used with caution, as its numbers are all estimates although built upon a framework of logic.

2. Across the top of the table, columns are provided for orbital periods in minutes, combined with matching circular altitudes in kilometers. Typical launch vehicles are listed in the right hand column, with separate lines for some of the most common orbital inclinations used in flights of that vehicle. With this grid constructed, the numbers filled in represent approximate payload lifting capacities in kilograms. These data are provided as a convenience to supplement the single figure for due east launchings at 200 kilometers, used in certain earlier tables.

3. Following the main table which covers altitudes between 170 and 1,500 kilometers is a supplementary table for the few vehicles which have been used for more distant orbits or escape flights, and the inclinations are those used at launch in flying to a Molniya type eccentric 12-hour orbit, a geostationary orbit, or for flights to the Moon and planets. It may be noted that it seems to be a more simple task to send a given weight of payload to the Moon or planets than to get from the Tyuratam launch site to a fixed position over the Equator. The end result is not precision, but at least an order of magnitude approximation which will help the user have general sense of what to expect from particular Soviet launch vehicles. These numbers in turn make it possible to estimate the upper limits for particular classes of known payloads which may fly at different inclinations or altitudes, to make sure that such estimates do not exceed the estimated lift capacities of the launch vehicle for some of the various orbits used for that class of payload.

4. In addition to the referenced eccentric and escape missions, many Earth orbital missions in practice are eccentric. The table assumes circular orbits, but the orbital periods can be applied to describe eccentric orbits as well; in actual practice, there may be added payload costs to add an extra stage, or to conduct a second burn of an engine to circularize the orbit, with some differences among the stable of vehicles.

SOURCES.—The basic data which are firm have come from Tass announcements, as explained in previous tables of this study, and then the table has been elaborated as explained in the notes above. Principal Western students of these vehicles have been Phillip S. Clark and Anthony Kenden in the United Kingdom, and Charles P. Vick and Saunders Kramer in the United States. Analysis appears in articles in Spaceflight, London.

THE STANDARD LAUNCH VEHICLE SERIES ("A")

THE ORIGINAL VERSION—A

Some time in the early 1950's a large Soviet rocket engine was developed for use in connection with the first ICBM, and it may have been considered even at the outset for space work as well. The Russians designated this the RD–107. The engine burns kerosene and liquid oxygen, uses a single shaft turbine assembly to pump the oxidizer and fuel to four combustion chambers with exit nozzles and to two steering rockets. There are auxiliary systems to pump a hydrogen peroxide gas generator and to run a liquid nitrogen to nitrogen gas pressure supply. The engine operates at 60 atmospheres to produce a vacuum thrust of about 102 metric tons with an I_{sp} of 314 seconds. A variant of the same engine is called the RD-108, differing from its predecessor primarily in having four steering rockets instead of two, and its vacuum total thrust is 96 metric tons. The first ICBM which also became the launcher for Sputnik 1 was assembled by placing four long tapered tanks of roughly cylindrical shape around a sustainer core. Each of these strap-ons had an RD-107 engine and the central unit had an RD-108. All five units with their 20 main nozzles and 12 steering rockets are ignited on the pad, and as soon as thrust builds up to lift off the pad, the rocket rises. When the boost task is over, the four strap-ons fall away leaving the sustainer core to continue burning for a time.

The total assemblage creates a fairly graceful impression. The central sustainer core, 28 meters long, described from the ground up starts as a regular cylinder, then flares outward, and tapers back again, creating a hammer head effect. This peculiar shape was selected to blend with the four strap-ons which are modified elongated tapered cones. When all five units are strapped together, the result is a fluted pyramid effect with a maximum base diameter of 10.3 meters, including the four stubby fins.

This is the vehicle which the Russians claim first flew as their original ICBM from Tyuratam on August 3, 1957.[33] Then it was used for the launch of Sputnik 1 on October 4, 1957, and likewise for the next two Sputniks. The vehicle in the "A" configuration is shown in figure 8. During that period the rocket had no upper stage, so it was not used very efficiently for payload weight purposes. The entire sustainer core was placed in orbit on these occasions, and one of the blurred Western photographs taken of such a rocket tumbling in orbit definitely suggests its hammerhead shape which has since been revealed by the Russians. Judged by the weight of the last and heaviest of these payloads, the lifting capacity of the rocket was about 2 metric tons to low circular orbit. It is possible that the residual weight of the spent rocket casing was on the order of 6 metric tons.[34]

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[33] Moscow Radio, 0800 GMT, Aug. 2, 1967.

[34] Scarullo, J. J., et al. Aerospace Ranges: Instrumentation, Van Norstrand, 1965, p. 107.

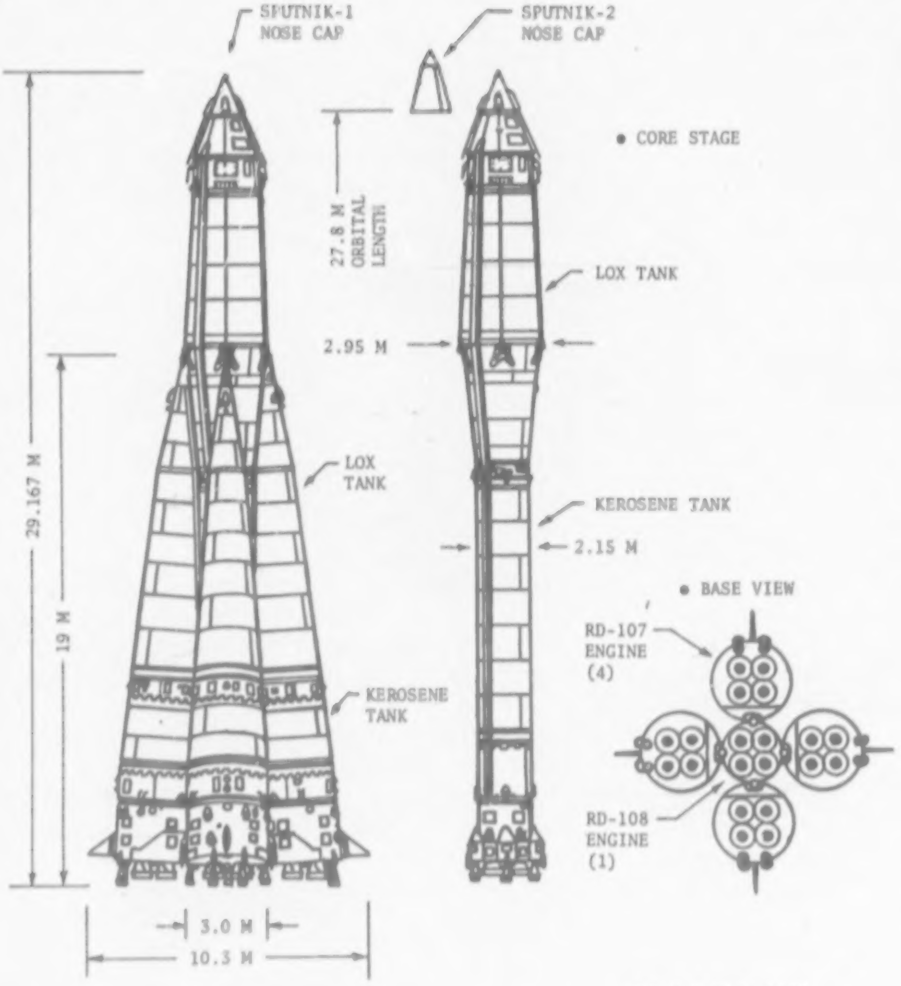
SPUTNIK-1 NOSE CAP
SPUTNIK-2 NOSE CAP
• CORE STAGE
27.8 M ORBITAL LENGTH
LOX TANK
2.95 M
29.167 M
19 M
LOX TANK
KEROSENE TANK
2.15 M
• BASE VIEW
RD-107 ENGINE (4)
KEROSENE TANK
RD-108 ENGINE (1)
3.0 M
10.3 M

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FIGURE 8. Standard launch vehicle in the A configuration used for launching the first three Sputniks.

With the announced weight of Sputnik 1 at under 84 kilograms, it is understandable why Western observers in that period postulated the use of a much smaller launch vehicle than the real one. When people rushed out of doors to see the passing of the first satellites, usually they were really viewing that 28 meter rocket casing, like a Pullman railway sleeper tumbling end over end, rather than the spherical Sputnik 1, 0.58 meters in diameter, or even Sputnik 3 which was 3.76 meters long. Sputnik 2 remained attached to its rocket.

Some time later, when the United States launched the Project Score satellite in the same mode as Sputnik 2—namely, leaving the payload attached to the spent rocket casing—it injected the entire sustainer portion of the Atlas launch vehicle into orbit. The United States announced achievement of the world's heaviest satellite to date (3,969 kilograms). The useful payload was actually about 68 kilograms. This provoked Leonid Sedov of the Soviet Union into some testiness, when he pointed out that the total weight in orbit in connection with each of the three Sputnik launches had been in excess of the U.S. weight. The residual Soviet weight has been assumed to be about 6 metric tons, and the Sputnik 2 vehicle which like Score remained attached to the rocket body weighed 508 kilograms for a total combined weight of perhaps 6,508 kilograms.

WITH THE LUNAR UPPER STAGE, A-1

Considering the lead times involved in developing space vehicles, it is likely that well before the time of Sputnik, the Russians were designing and building an upper stage to fit on their original model ICBM, and this raised its orbital capacity to 5,000 kilograms, though its first use was for direct flights to the Moon with a net payload weight of about 400 kilograms.

This upper stage used for the Luna 1, 2, and 3 flights was the first Soviet spacecraft to be put on public display in replica. Mounted on top of the sustainer core by an open truss structure, it measures about 3.1 meters long and has a diameter of 2.58 meters. Strangely to this date the Russians have not announced the designator for the single nozzle engine or given its thrust. Its thrust should be on the order of 5 metric tons. We are left with a mystery in the Soviet accounts. They reported for some years that the total thrust of all the engines was 600 metric tons. Having then told us that the five engines of the core and boosters had a thrust of 102 metric tons each, by subtraction the upper stage thrust should have been 90 metric tons, which would have put a heavy G load on this stage when it fired. This is the amount of thrust of the Soviet RD-219 upper stage engine, but it has two nozzles, and the lunar stage engine has only one nozzle. When this rocket was used for the direct flights to the Moon, the lunar stage was accelerated to a speed sufficient to send it to the Moon along with the payload. The combined weight of spent rocket and payload was on the order of 1,500 kilograms. The lunar version of A-1 is shown in figure 9. Another hypothesis considers these launches to be precursors of F-launched ocean surveillance satellites.

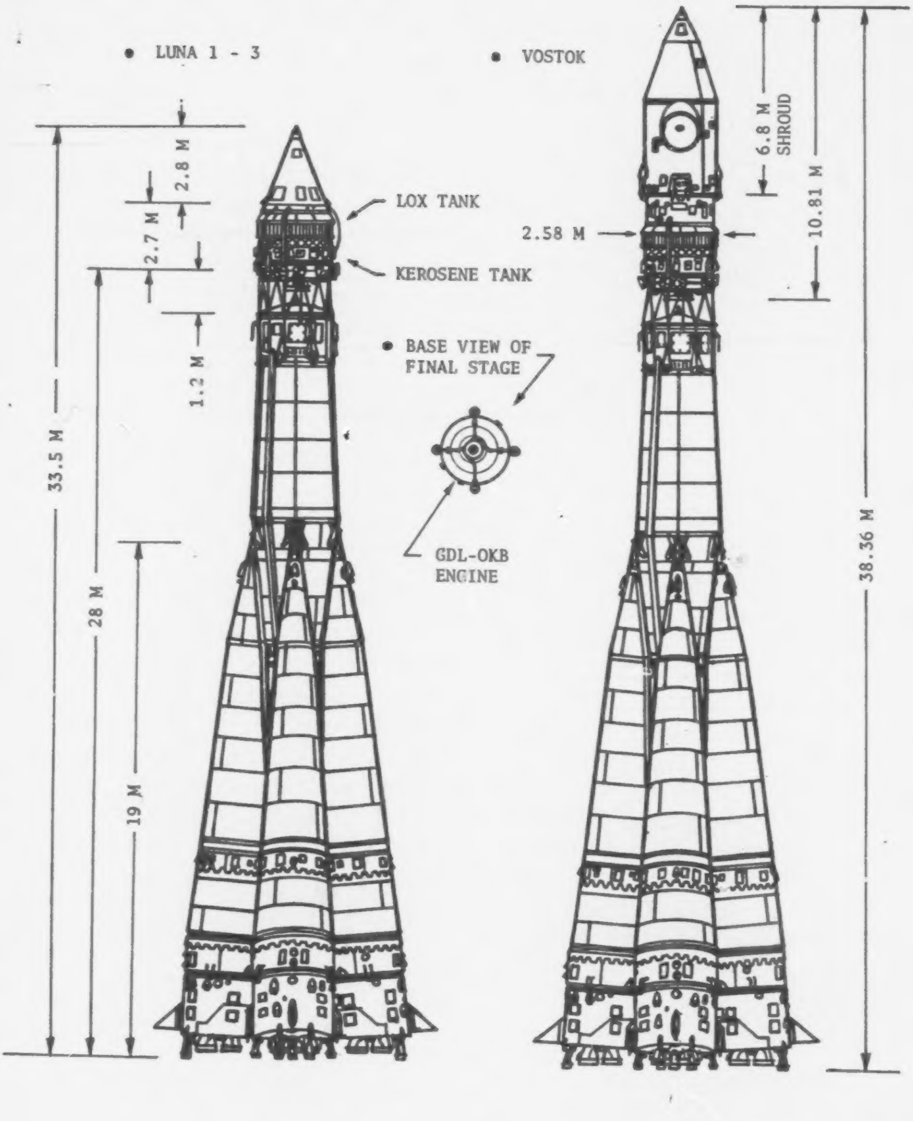
• LUNA 1 - 3
• VOSTOK
2.8 M
2.7 M
1.2 M
33.5 M
28 M
19 M
LOX TANK
KEROSENE TANK
2.58 M
6.8 M SHROUD
10.81 M
38.36 M
• BASE VIEW OF FINAL STAGE
GDL-OKB ENGINE

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FIGURE 9. Standard launch vehicle with the first type of added upper stage, A–1, (a) as used to launch the first three Luna spacecraft, (b) as used to launch the six Vostok manned spacecraft.

When the Russians were ready to begin test flights leading toward placing man in orbit, they used this same upper stage on the original launch vehicle. It was not until 1967 that a replica of Vostok 1, shown in figure 9b, was put on public display (Paris Air Show), and indeed, the upper stage of that assembly was essentially the same as the earlier unveiled lunar stage of 1959.

It was mentioned that at first Western analysts thought a much smaller rocket had been used by the Russians for the launch of Sputnik 1 because that payload weighed only 84 kilograms, and people at first were unaware of the great weight of accompanying rocket stage also in orbit. A second factor in the underestimation was the difference in design philosophy. For example, the early U.S. Atlas missile has such light construction that it had to be kept pressurized all the time to keep it from collapsing of its own weight in relation to skin thickness. This was done to maximize performance for a given size of vehicle. By contrast, when the Soviet launch vehicle arrived by ship at Rouen, France, observers were fascinated to note that the core and boosters were unloaded with cables attached at opposite ends, and workmen could walk the length of the empty rockets. The implication was the Russians did not feel weight-limited, and had built rugged vehicles which still permitted them to carry the payload they wanted, within reasonable limits.

WITH THE PLANETARY UPPER STAGE, A-2

The Luna and Vostok version of the standard vehicle did not exploit the total potential of the first stages, and so an improved stage was built which began to fly as early as 1960. Its first public disclosure came in 1961 in connection with the Venus attempts of that year. The Luna upper stage was replaced by a stage 8 meters long. It was able to send about 1,500 kilograms of payload to the Moon, not counting the weight of an escape rocket, and over a period of time the capacity was raised. Without an escape rocket it was used to increase the Earth orbital capacity. The first announced use in Earth orbit was to put up 6,583 kilograms, and subsequently, the capacity has been described by them as 7,500 kilograms maximum. It was used for the pair of Voskhod manned flights, and has continued in use to the present time in the Soyuz manned flights. In addition it is the version most used in the Kosmos program for those flights which perform a military mission followed by recovery after some days. The Voskhod and Soyuz versions of A-2 are shown in figure 10.

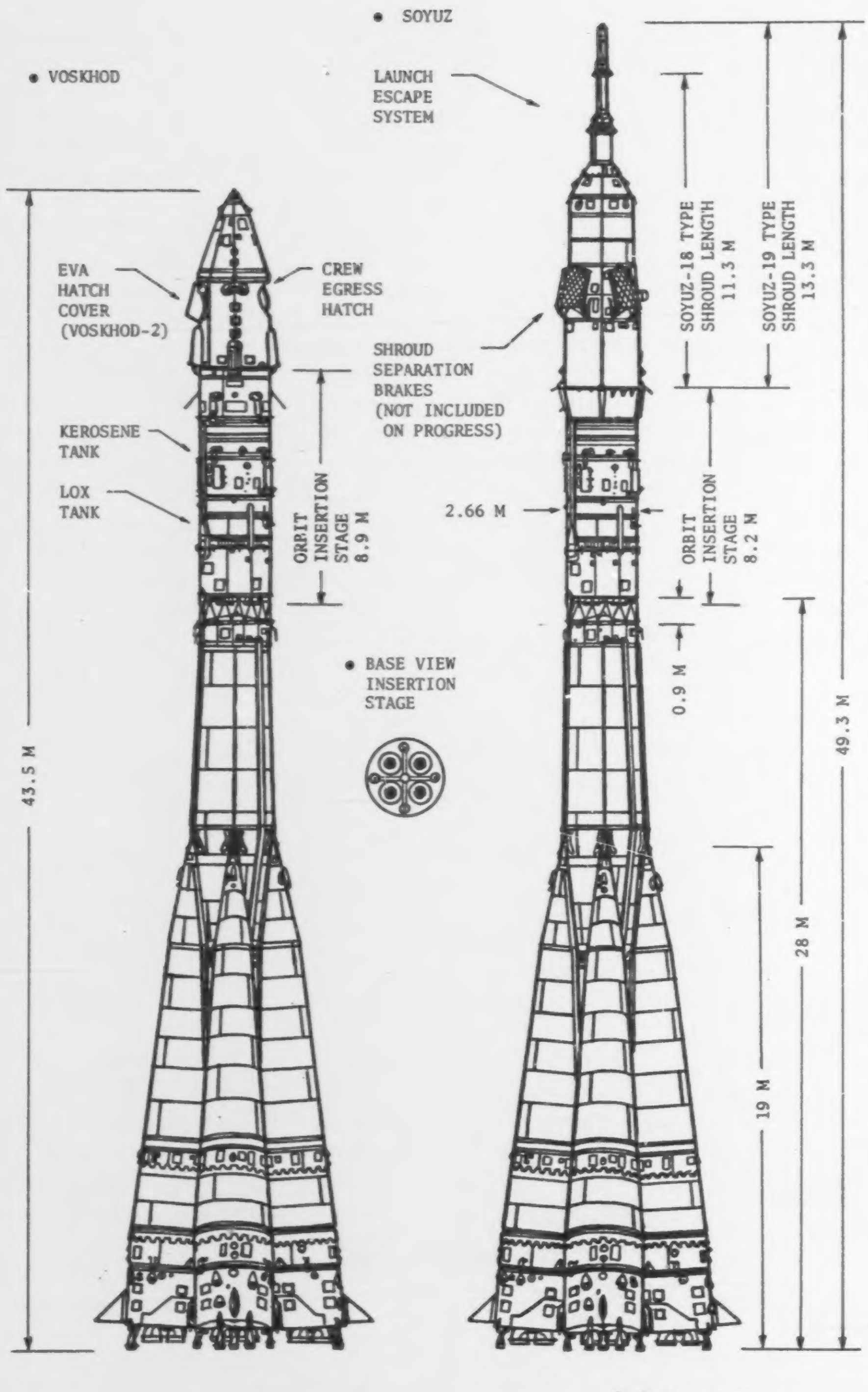
• VOSKHOD
EVA HATCH COVER (VOSKHOD-2)
CREW EGRESS HATCH
KEROSENE TANK
LOX TANK
ORBIT INSERTION STAGE 8.9 M
43.5 M
• BASE VIEW INSERTION STAGE
• SOYUZ
LAUNCH ESCAPE SYSTEM
SHROUD SEPARATION BRAKES (NOT INCLUDED ON PROGRESS)
SOYUZ-18 TYPE SHROUD LENGTH 11.3 M
SOYUZ-19 TYPE SHROUD LENGTH 13.3 M
2.66 M
ORBIT INSERTION STAGE 8.2 M
0.9 M
49.3 M
28 M
19 M

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Figure 10. Standard launch vehicle with the improved upper stage, A-2, (a) as used to launch the two Voskhod manned spacecraft, (b) as used to launch the Soyuz manned spacecraft.

It is the Soviet practice to disclose information only piecemeal about their vehicles. In the case of the Vostok it was years before they disclosed the thrust of the rockets or their number. The sole statistic beside the orbital weight was an output of 20 million horsepower, not a common measure for describing the power of rockets. As mentioned they later said the combined thrust was 600 metric tons from 6 engines.

When the Voskhod flights came, they said the rocket had 7 engines of 650 metric tons. No replica was put on display, so that analysis in the West was made more difficult. Subtraction of the announced thrust of the 5 core and booster engines seemed to leave 140 metric tons of thrust for an upper stage of 2 engines. This was not logical for the purposes or for the observed behavior of the flights. It is only in 1975 that we finally have a fresh Soviet statement on this rocket combination. First of all, they have adjusted downward the thrust of the central core rocket to list it at 96 metric tons, giving 504 metric tons for the combined thrust of the core and boosters. Now they list the same upper planetary stage, as used for Soyuz as having a thrust of 30 metric tons. The stage is powered by a single engine with four combustion chambers and nozzles. There is no clue as to how to reconcile the 534 metric tons of combined thrust in Soyuz with the 650 metric tons quoted for the same stages in the Voskhod of many years earlier. We still do not know what the seventh engine alluded to earlier meant, as only six can be counted.

The mystery of why the Soviet listed thrusts ran ahead of normal reality was finally solved in 1975. Maarten Houtman of Amsterdam was talking with a Soviet engineer at the Paris Air Show, and was told that the 600-metric ton figure for thrust was found by adding together the combined thrust of 4 RD-107 engines at 102 tons each, plus the RD-108 engine at 96 tons, for a total of 504 tons, and then adding to that the thrust of the same RD-108 which continued to burn after the 4 strap-ons dropped away, making the total of 600. The arithmetic is impeccable, but it seems a most peculiar way to count total thrust, and it still ignores the thrust of the final stage.

A review of the book by Leonid Vladimirov shows that he published in 1971 the thrusts of the Vostok (A-1) rocket 4 years ahead of the 1975 Soyuz disclosures on the same rocket, and he further had information that the mysterious upper stage had a thrust of 11 tons, which is consistent with the RD-119 engine to be discussed presently.[35]

WITH PROBE ROCKET ADDED, A-2-e

The A-2 version, just described, was itself a step back from the A-2-e, already partly described and shown in figure 11. In this version, there was indeed a seventh engine, in contrast to Voskhod and Soyuz. This added stage when used is contained within the shroud which covers the payload. The Russians after Luna 3 used consistently a special technique for their flights which required an extra stage. This was especially important for flights more nearly in the plane of the Equator, since the Soviet launch sites are at relatively northern latitudes. The rocket assembly is launched from the cosmodrome to place the interplanetary larger stage plus the payload in low circular Earth orbit, where the burned out stage is separated. During the course of the first orbit as the payload heads northeast across the South Atlantic to cross Africa, a special orbital launch platform, never specifically described as to shape, dimensions, or weight, is oriented and from it the final payload is launched to higher speed by the escape rocket. This probe rocket, after it has done its work, is separated from the payload and flies on essentially the same path as the payload. It has not been described in detail in Soviet publications available in the West. However, it was shown diagrammatically in a Soviet pamphlet written in German, "Nachrichtenbruke in Kosmos" which described Molniya 1. This has subsequently been issued in English: "A Satellite's Overhead." The stage is shown as a stubby cylinder measuring about 2 meters in diameter and perhaps 2 meters long. Soviet payloads which are launched from the orbital launch platforms and given their impetus with this added escape stage also carry a special maneuvering engine for orbit adjustments and smaller verniers for orientation.

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[35] Vladimirov, Leonid. The Russian Space Bluff. London, Tom Stacey Ltd., 1971, p. 83.

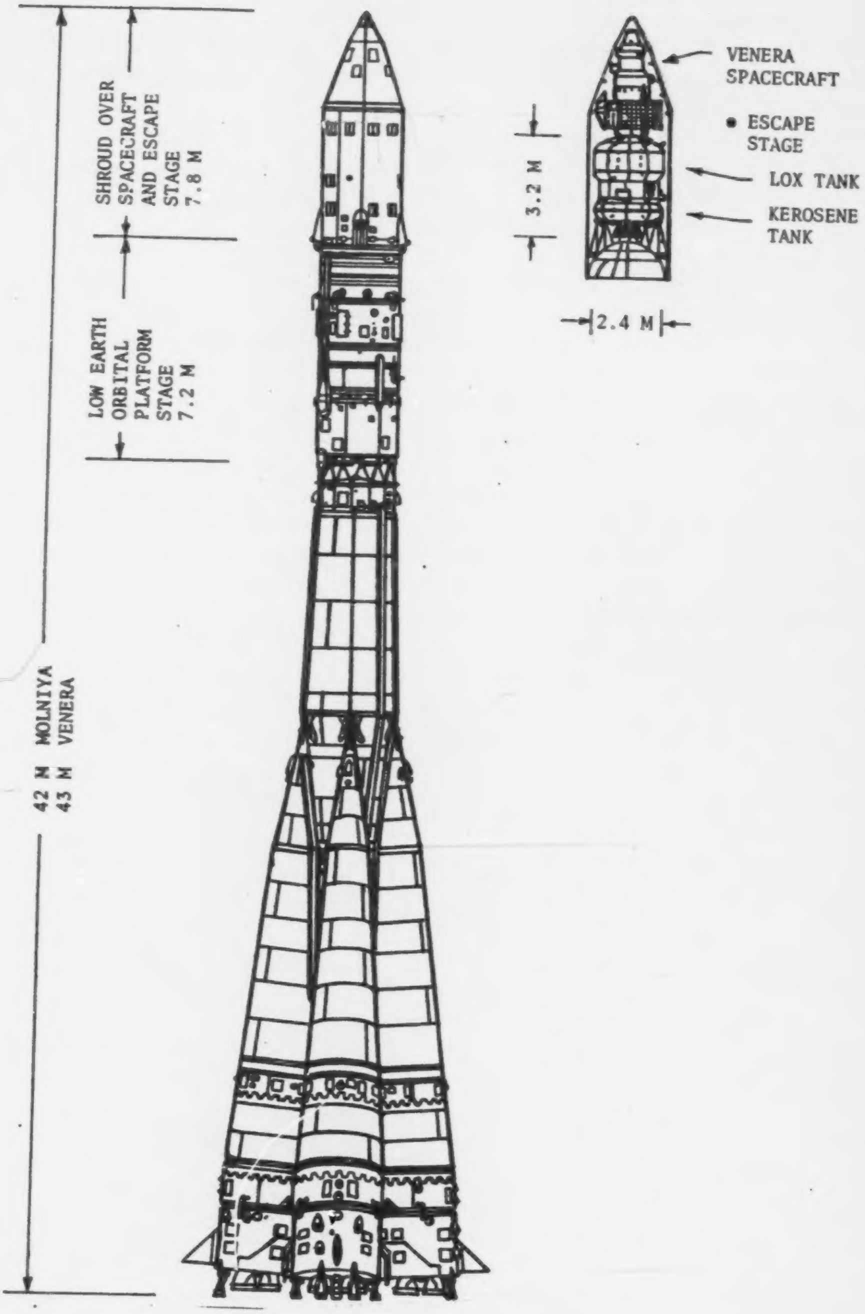
SHROUD OVER SPACECRAFT AND ESCAPE STAGE 7.8 M
LOW EARTH ORBITAL PLATFORM STAGE 7.2 M
42 M MOLNIYA
43 M VENERA
3.2 M
2.4 M
VENERA SPACECRAFT
• ESCAPE STAGE
LOX TANK
KEROSENE TANK

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FIGURE 11. Standard launch vehicle-with improved upper stage and an escape stage, A-2-e.

When this whole system works, it does a very effective job. The Soviet program is given added flexibility as to launch windows through the technique of orbital launch, and calculations can be made as to the final stage firing in the relative tranquility of the vacuum of space. This flexibility is important for the Russians who have lacked the worldwide network of land-based tracking and control stations which the United States has developed in cooperation with other nations. But the number of steps required to carry out a deep space mission, supported by automatic devices and a few ships, tended to expose these operations to a fairly high failure rate. Assuming that in general Soviet flight successes and failures are comparable to those of the United States because competent people in both countries are applying the same technology, then we see no particular reason why Soviet Earth orbital operations should be any less successful than those of the United States. But deep space work with the platform launch technique presents in fact another story. For example, the United States has made 65 launch attempts for escape missions, of which only 11, or 17 percent, have failed to escape. The Soviet Union has made an unpublished number of attempts to use the orbital launch technique, but we can note that of 68 Earth orbiting platforms carrying payloads intended for the Moon, Mars, or Venus, 20 failed to send their probe payloads beyond Earth orbit, or a failure rate of 29 percent, higher than the U.S. rate. The total failure rate is undoubtedly higher for deep space missions because additional flights presumably did not even attain Earth orbit. However, in the period 1976–80, both countries achieved complete success in the attempts to launch escape missions—six for the United States and three for the Soviet Union.

WITH THE MANEUVERING STAGE, A-m

Late in 1963 and again in 1964, the Russians flew payloads with the name Polyot, and these were heralded as but the first ones of a large series. In actual fact, no more flights occurred with exactly the same characteristics, and the name itself was not used again.

What was distinctive about these flights was that they came early enough in the Soviet program and were ambitious enough in performance for their being an application of the A vehicle. They were launched from Tyuratam. Each was advertised to have made extensive changes of altitude and also of orbital plane. However, the amount of plane change was not specified, and it is doubtful that it was very large. Neither flight left a separated carrier rocket in orbit as a guide to how extreme the subsequent maneuvers were of the final payload. So apparently the A-1 or A-2 were not used for these launches, but some experimental maneuvering stage which remained attached to the payload. Either this combination did not work out as hoped, or the "m" stage subsequently has been incorporated into other hardware, to be discussed later.

A POSSIBLE A-1-m CONFIGURATION

There were two more engineering test flights which bore at least a partial resemblance to the Polyot flights. These occurred in 1965 and 1966 under the labels Kosmos 102 and 125. There were no separated carrier rockets accompanying the flights, and their location of perigee in the southern hemisphere suggested that their lunar type stages had been only suborbital with an integral upper stage firing half way through the first orbit to put the apogee back in the latitude of the launch site. It is a temptation to consider this a further development of the use of the "m" stage, but without Soviet data, it is not provable. A review of the Polyot missions and those of Kosmos 102 and 125 has recently appeared in Spaceflight.[36]

A POSSIBLE A-2-m CONFIGURATION

In 1970 and 1971 there were three similar flights (Kosmos 379, 398, and 434), of which the last was eventually acknowledged to be a test flight of an experimental "luna kabina." They behaved a little like regular A-2-e vehicles in that they abandoned an interplanetary type stage in low Earth orbit after their launch from Tyuratam. Later they abandoned some piece of hardware in an eccentric orbit which reached out to approximately 1,200 kilometers. After this a maneuvering engine integral with the payload carried the flight to a distance of between 11,000 and 14,000 kilometers, depending on the flight. It is permissible to label this series of flights as using the A-2-m configuration in which the "m" stage represents the engine(s) of the lunar module.

THE SMALL UTILITY LAUNCH VEHICLE ("B")

Just as the United States looked to the Redstone, Thor, Jupiter, Atlas, and Titan in the missile inventory to serve as first stages of space launch vehicles, the Russians also saw the logic of applying the results of extensive military R&D. As discussed, the original ICBM, SS-6 or Sapwood became the standard Soviet launch vehicle from 1957 to the present time, with its lift capability gradually improved to as much as 7.5 metric tons. Even with the economies of serial production, this is still an expensive way to put up every payload whose weight may be a small fraction of 7.5 metric tons.

Moscow parades of military hardware had revealed medium range and intermediate range missiles which should have been quite capable of serving as the first stage of space launch vehicles. One of these, the SS-3 or Shyster was later pictured by the Russians as the largest of four classes of vertical probe rockets used for geophysical payloads and biological flights launched at Kapustin Yar during the late 1950's. Shyster was replaced in parades by an improved version which may have a range of about, 1,600 kilometers instead of about 1,000 kilometers such as its predecessor. This newer model was code named SS-4 or Sandal. It was the principal rocket which showed up in Cuba during the fall of 1962, so its picture became well known in the United States.

Kapustin Yar, a primary base for test flights of the Shyster and then the Sandal missile, came into use as a space orbital launch site in March of 1962 when Kosmos 1 was announced. The small Kosmos flights, all flown at close to 49 or 48 degree inclinations would have been ideally launched by the Sandal, and that was the conclusion of Western analysts for 5 years. No specific weights were announced for these groups of Kosmos payloads, strongly suggesting that there would be a large military component among them. However, from a study of the replica payloads which have been put on display, this vehicle should be able to lift from 260 to

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[36] Clark, Phillip S. The Polyot Missions, Spaceflight, vol. 22, pp. 312-315, London, Sept.-Oct. 1980.

425 kilograms to orbit. A Soviet official at the Montreal Expo told David Woods the range was 280 to 600 kilograms. In 1967 at the Paris Air Show, the Russians put on display for the first time the RD-119 upper stage engine used for this launch vehicle. It had been developed between 1958 and 1962 at the Leningrad Gas Dynamics Laboratory. Its design concept was a little like the RD-107 and RD-108 from the same source. It operates at a pressure of 80 atmospheres, has a thrust of 11 tons, and a vacuum I_{sp} of 352 seconds. It burns unsymmetrical dimethyl hydrazine (UDMH) and perhaps liquid oxygen. The single nozzle is bell-shaped, and a single shaft turbo pump system drives the fuel and oxidizer supplies as well as a fairly elaborate set of auxiliary nozzles for roll, pitch, and yaw.

Late in 1967, with the expansion of the Moscow Museum of Industrial Achievement, a total assembly of this small Kosmos launcher was put on display. This confirmed the analysts had been right: It did use a modified SS-4 Sandal first stage, with an added upper stage powered by the RD-119. The SS-4 and the B-1 are shown in figure 12. Some of the payloads it puts up are spin stabilized, and then the carrier rocket upper stage is separated. In at least one case, the payload was not separated. In another case, two payloads were put up in a single launch. Twice, a special aerodynamic stabilization was used. More recently the first stage rocket engine has been displayed as the RD-214. It has four nozzles, burns kerosene in refined form and nitric acid. Its thrust is 74 tons, the I_{sp} is 264 seconds, and its chamber pressure is 45 atmospheres.

Articles in Clark's series of studies of Soviet launch vehicles dealing with the B-1 and its payloads at the 71 degrees inclination have appeared in Spaceflight.[37] [38]

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[37] Clark, Phillip S. The Sandal Program, Spaceflight, vol. 23, pp. 18-21, London, May 1980.

[38] Clark, Phillip S. Cosmos Flights at 71 Degrees, Spaceflight, vol. 22, pp. 174-177, London, May 1980.

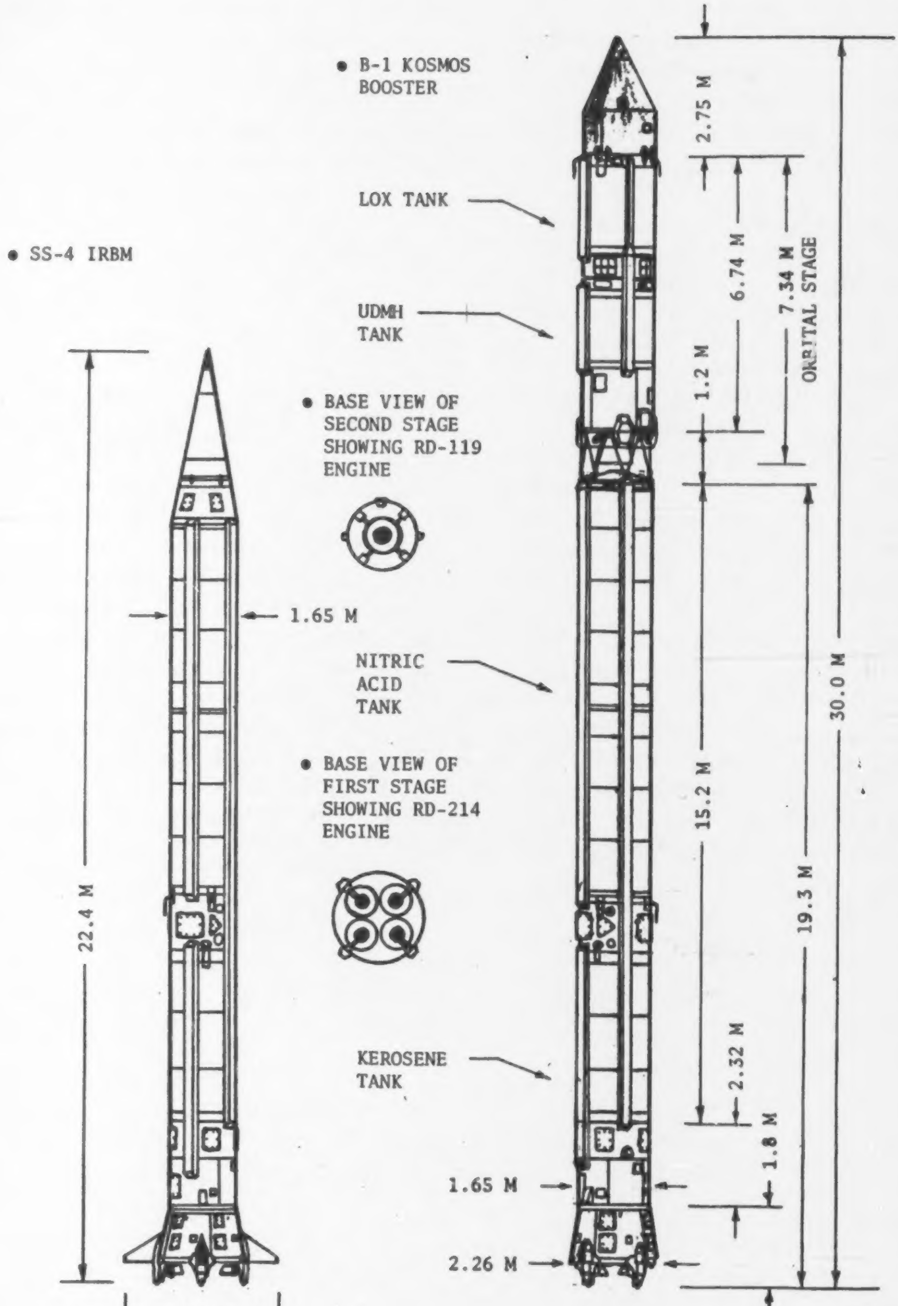
• B-1 KOSMOS BOOSTER
LOX TANK
• SS-4 IRBM
UDMH TANK
• BASE VIEW OF SECOND STAGE SHOWING RD-119 ENGINE
1.65 M
NITRIC ACID TANK
• BASE VIEW OF FIRST STAGE SHOWING RD-214 ENGINE
22.4 M
KEROSENE TANK
3.66 M
2.75 M
6.74 M
7.34 M ORBITAL STAGE
1.2 M
30.0 M
15.2 M
19.3 M
2.32 M
1.8 M
1.65 M
2.26 M

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FIGURE 12. (a) SS–4 intermediate-range ballistic missile, and (b) minimum launch vehicle, B–1.

The B vehicle would now appear to have been phased out of service, its role having been assumed by the C–1. The last B–1 launch placed Kosmos 919 into orbit from Plesetsk on June 18, 1977.

Although this study is devoted to the space program and not to military hardware per se, so much reference is made to military surface-to-surface missiles, many of which are also used for space purposes that table 10 has been included to give a quick reference check list of the better known of these.

THE FLEXIBLE INTERMEDIATE LAUNCH VEHICLE ("C")

Small, relatively modest Soviet payloads for 5 years came only from Kapustin Yar, and after that also from Plesetsk, but not from Tyuratam. In 1964, however, a new series of flights began at Tyuratam with a vehicle which was neither a B–1, nor the large A class. It can be designated the C–1, and starting in 1967 it also came into use at Plesetsk. It was first used for a space launch from Kapustin Yar in 1973.

As first used, it put up multiple payloads, initially three at a time, then five at a time, and now eight at a time. Starting at the end of 1965 and most of the flights since have been single payloads. The earliest launches were in eccentric orbits, and then came flights with circularized orbits, and these have been at increasing altitudes.

This performance seemed in excess of what could be expected of the B–1 launch vehicle both because of the many multiple payloads, and the domonstrated capacity to achieve circularized orbit at higher altitudes. In addition to that the appearance of the flights from a cosmodrome not used for the regular small Kosmos or B–1 flights was a further indication. Even where flights of the B–1 and the C–1 come from the same cosmodrome, there are marked differences in inclination, suggesting the use of different launch pads.

As Western analysts sought a military missile which might fit the needs of a first stage of the C–1, the SS–5 of Skean came to mind. This had been paraded in Moscow, and was believed to have a range as a missile of close to 4,000 kilometers. It was also known as the missile which followed the Sandal into Cuba and posed an added threat then because of its greater range. The SS–5 and the C–1 are shown in figure 13.

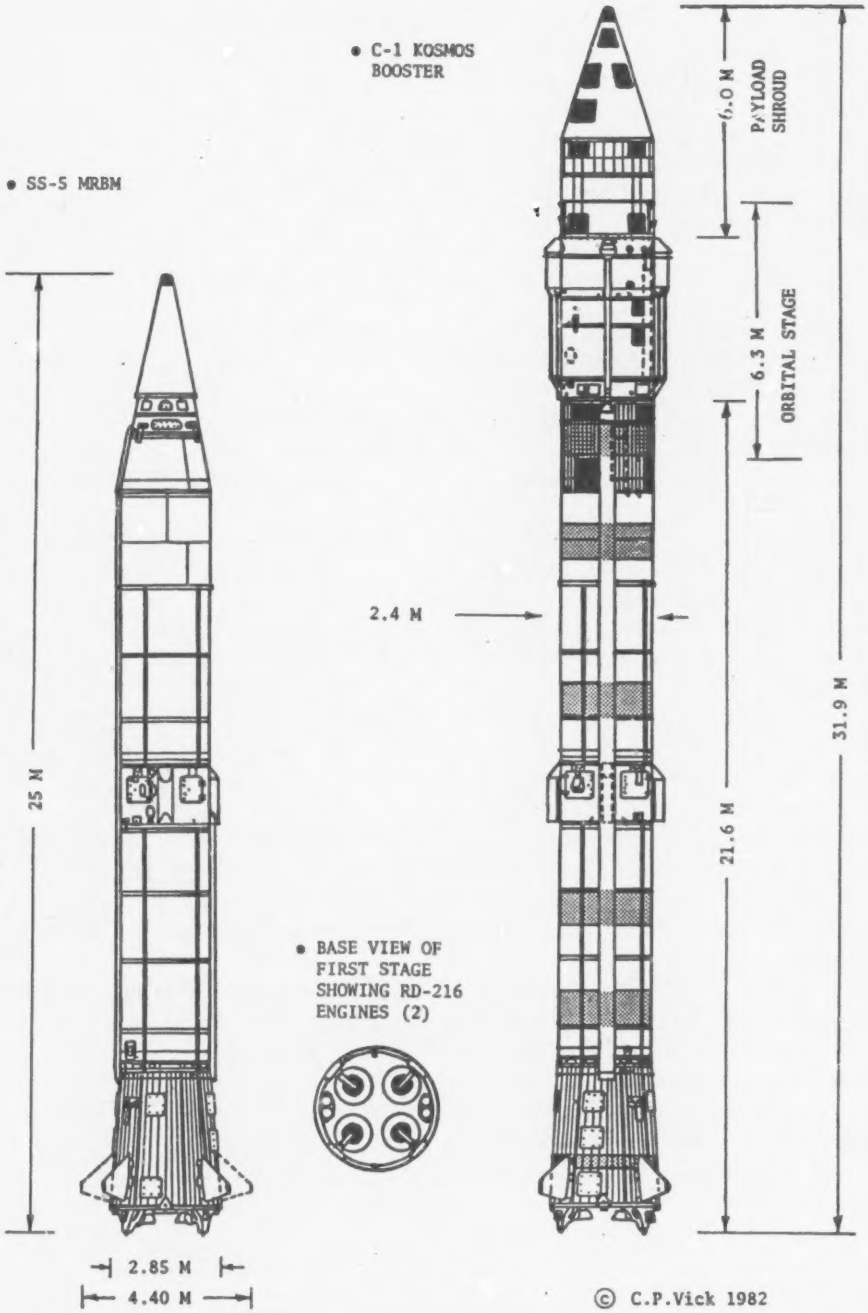
• C-1 KOSMOS BOOSTER
• SS-5 MRBM
6.0 M
PAYLOAD SHROUD
6.3 M
ORBITAL STAGE
2.4 M
31.9 M
25 M
21.6 M
• BASE VIEW OF FIRST STAGE SHOWING RD-216 ENGINES (2)
2.85 M
4.40 M
© C.P.Vick 1982

FIGURE 13. (a) SS-5 medium-range ballistic missile and (b) intermediate capacity launch vehicle, C-1.

The Skean-based C-1 type of launch vehicle has not yet been put on display by the Russians, but finally some photographs are appearing, and they confirm the use of this particular missile for the first stage. The first photograph was obtained in the West by Maarten Houtman of the Netherlands. The exact dimensions are not known, but some ratios have been developed by Phillip S. Clark.[39] The vehicle may be 2.44 meters in diameter and about 31.6 meters long. It probably could put over 1,000 kilograms into low Earth orbit but has not been used that way. More likely the payloads range from about 900 to 500 kilograms, decreasing with altitude. The initial reticence to disclose anything about its rocket engines or performance again suggest a role which is largely military. Even the Skean missile when paraded in Moscow carried a plate to hide its power plant. Kenneth Gatland reported that it had four nozzles and it was later found that the first stage was powered by two RD-216 engines, each with two chambers, fueled with unsymmetrical dimethyl hydrazine (UDMH) and nitrogen tetroxide.

THE NONMILITARY LARGE LAUNCH VEHICLE ("D")

In the United States the time came when occasional needs for putting up large space payloads exceeded the capacity of existing varieties of military missiles, and hence the Saturn I and IB were created. They grew out of preliminary designs of the Army Ballistic Missile Agency Redstone Arsenal team headed by Wernher von Braun. Much the same need must have been felt in the Soviet Union, and they, too, have created their first nonmilitary missile vehicle for space purposes. Some Western analysts speculate it was first designed as a super ICBM to carry the 100 megaton city buster warheads that Premier Khrushchev talked about. In any case, its flight test program has been limited to space work.

THE BASIC VEHICLE, D

The first launch of a new large vehicle came in July 1965, with a payload named Proton 1, and said to weigh 12.2 metric tons. The payload replica was put on display and it had a cylindrical cross section of about 4 meters. When the payload was orbited, it was accompanied by a separated spent carrier rocket stage. Published Western estimates of this stage have ranged between 12 and 27.7 meters in length, and these different figures in turn have raised issues not fully resolved about the first three Proton flights.

The vehicle has not yet been put on public display, even though it has been flying for 10 years, nor has a complete photograph been shown. Motion pictures of launches, released in the last year or so tantalizingly show the upper stage and payload, and also the attachment points of strapped on boosters. Inflight pictures are too fuzzy to do more than reveal that there are six boosters firing at the time of ascension from the launch pad at Tyuratam.

The first careful drawing of the vehicle based upon these partial looks was done by Peter Smolders of The Netherlands.[40] He postulated that the general appearance was that of a scaled up A class vehicle with six instead of four boosters. Subsequently, closer study by Charles P. Vick and others in the United States builds a case for the same essential operation of boosters, but that these may be regular cylinders through most of their length rather than the tapered design used for the A class vehicles. There may be a brief transition at the upper end into a conical fairing to the point of attachment to the sustainer core rocket.[41] Vick's concept is shown in figure 14. Since ground observations of the orbital stage show it to be too short to be the core, this shows a final, insertion stage on top of the sustainer core. A more recent review by Clark has appeared in Spaceflight.[42]

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[39] Clark, Phillip S. The Skean Program, Spaceflight, vol. 20, pp. 298–304, London, August 1978.

[40] Smolders, P. L. L. Soviets in Space. London, Butterworth Press, 1973, pp. 70–71.

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[41] Vick, Charles P. The Soviet Superboosters—1. London, Spaceflight, December 1973, pp. 457-471.

[42] Clark, Phillip S. The Proton Launch Vehicle. London, Spaceflight, vol. 19, pp. 330-333, 340, September 1977.

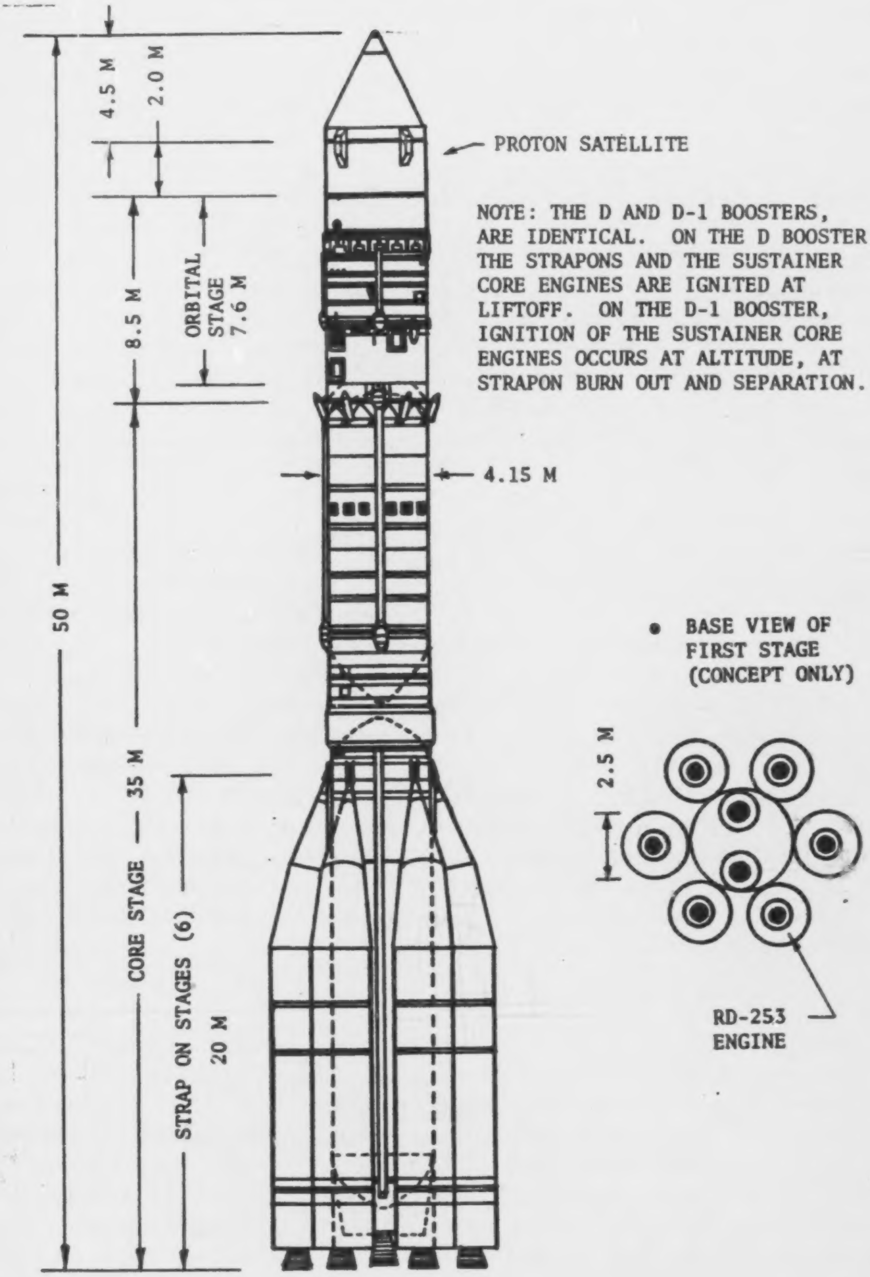
4.5 M
2.0 M
PROTON SATELLITE
NOTE: THE D AND D-1 BOOSTERS, ARE IDENTICAL. ON THE D BOOSTER THE STRAPONS AND THE SUSTAINER CORE ENGINES ARE IGNITED AT LIFTOFF. ON THE D-1 BOOSTER, IGNITION OF THE SUSTAINER CORE ENGINES OCCURS AT ALTITUDE, AT STRAPON BURN OUT AND SEPARATION.
8.5 M
ORBITAL STAGE 7.6 M
4.15 M
50 M
• BASE VIEW OF FIRST STAGE (CONCEPT ONLY)
2.5 M
CORE STAGE — 35 M
STRAP ON STAGES (6) 20 M
RD-253 ENGINE

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Figure 14. The nonmilitary launch vehicle, D. The basic first stage is a concept based on indications from cine-films of launches, which show only the upper stage and payload, that there are six strap-ons. The basic first stage alone was used to launch the first three Proton satellites. It is shown here with an orbital stage, D-1, used to launch Proton 4.

When the first launch occurred the Russians heralded this vehicle as opening the door to many important space uses. These included the construction of manned space stations and unmanned flight to the planets. It was given a brief and nonexplicit description, generally said to produce about three times the horsepower of the A vehicle.

If one makes the assumption that the same design philosophy was used, and this seems borne out by the limited looks provided in Soviet films, then the vehicle should be much like an A vehicle scaled up in volume threefold (or 1.44 times linear), with the likely change that the boosters are mostly cylindrical. Holding to the same proportions, the basic vehicle sustainer core should be about 40.7 meters long. The combined thrust of the core plus six boosters should be on the order of about 1,542,000 kilograms, or close to 220 metric tons of thrust for each engine. Any simple threefold scaling presents contradictions. If one assumes the A vehicle would lift 3,000 kilograms, the D vehicle should lift about 9,000 kilograms. If the A-1 and A-2 lift in the range of 4,725 to 7,500 kilograms, then the D-1 should lift about 14,175 to 22,500 kilograms. The first three Proton payloads were 12,200 kilograms, not an ideal fit for the D or D-1. The fourth Proton at 17,000 kilograms was in the right range. If the estimated length of the accompanying orbital rocket for the early Protons was 27.7 meters, that is too short to be the sustainer core which may be 40.7 meters long, if operating in the "A" class burn sequence. The problems with both weight lifting capacity and length tend to minimize the chance that the first Protons were put up in the same fashion as Sputnik 1 through 3. We have to allow for the possibility of a D version but the case is not strong. Vick prefers the notion that the core vehicle is ignited at altitude rather than at ground level. But he suggests that if this long stage went into orbit, it might weigh enough to explain the relatively low payload weight of the first three Protons.

THE VEHICLE WITH AN ADDED STAGE, D-1

If the D vehicle was to demonstrate its potential in more ambitious flights, it needed one or more added stages, and, as discussed, may have had an additional stage from the outset. Applying the proportions of the A-2 interplanetary stage and scaling up threefold, its 8 meters should be about 11.6 meters on the larger vehicle. This is compatible with the 12 meter length assumed by the Royal Aircraft Establishment in its publications. Vick's speculative concept of the D-1 configuration is shown in figure 15.

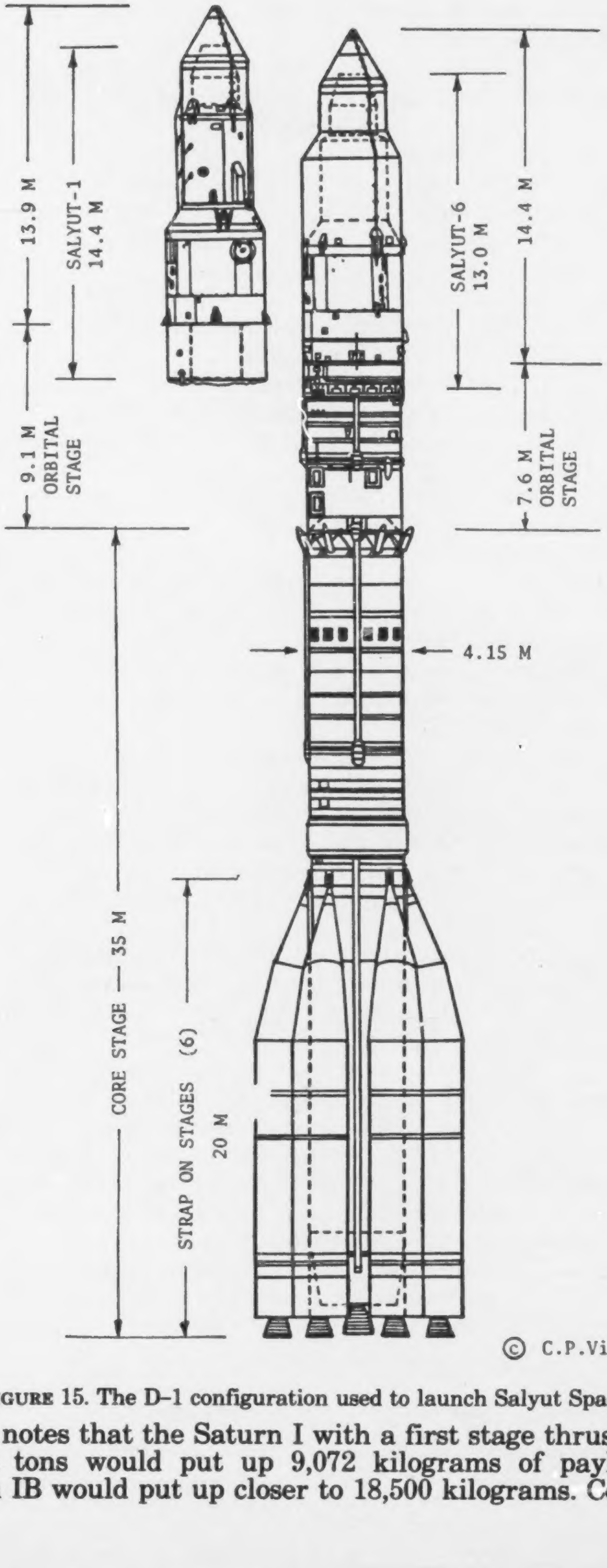
13.9 M
SALYUT-1
14.4 M
9.1 M
ORBITAL
STAGE
SALYUT-6
13.0 M
14.4 M
7.6 M
ORBITAL
STAGE
4.15 M
CORE STAGE — 35 M
STRAP ON STAGES (6)
20 M

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FIGURE 15. The D–1 configuration used to launch Salyut Space Stations.

One notes that the Saturn I with a first stage thrust of about 680 metric tons would put up 9,072 kilograms of payload, and the Saturn IB would put up closer to 18,500 kilograms. Considering the first stage thrust of the D class vehicles as perhaps 1,542 metric tons, then at the same level of efficiency and same use, the D class vehicles should have the potential to put up payload weights in the range of 20,570 to 41,950 kilograms. In fact, one must scale this back both because there is no evidence for the Soviet use of LOX-hydrogen fuel in upper stages, and because the launch site is less favorably located than Cape Canaveral. In addition to that is the Soviet design philosophy which tries to offset heavier structures for launch vehicles with more thrust, this combination being at the expense of payload weight.

An indication of the capacity of the D–1 is provided by Konstantin Feoktistov who quotes a maximum diameter of 4.15 meters and a length of about 13.5 meters for the payload.[43]

In the first half of 1967 came two Kosmos launches, 146 and 154. These were given routine announcement by the Russians, but British optical measurements showed a carrier rocket in orbit larger than the interplanetary stage of the A–2 rocket, and smaller than the possible 27.7 meter length associated by some estimates with the first Proton launches. The payloads were estimated at 14.2 meters in length by 3 meters in diameter. One must recognize that a small number of readings of an indirect nature which make some assumptions about shape and surface must render all measurements that are made very tentative. The British estimate at the time was that the payloads in question might lie in the 18,000 to 27,000 kilogram range. These numbers would square generally with use of the D–1 launch vehicle.[44]

What we do not know is whether these flights performed their missions as intended in low Earth orbit, or were intended to fire probe rockets (making them D–1–e) into some further trajectory. In a well reasoned analysis, Grahn and Oslender arrive at the conclusion that the natures of the two missions were completely different.[45] Considerations of the maneuvering of Kosmos 146, the transmission frequency and signal characteristics suggest that it might have been a thorough flight test of the Soyuz propulsion system in preparation for the Soyuz 1 mission which was to follow 5 weeks later. On the other hand this cannot be reconciled with the view that it was a large object launched by the D vehicle. The orbital parameters of Kosmos 154 were shown to be close to those of the Earth parking orbits of the later Zond series of lunar flights.

In November 1968, Proton 4 was launched into orbit, and seemed to be accompanied by a 12-meter spent rocket casing. The Russians announced a weight for the payload of 17 metric tons, reasonably close to the Western estimate of 18 metric tons for the D–1.

The first Salyut space stations also put up by the D–1 seem to have had a weight of about 18.6 metric tons. With reports that they are likely in the future to grow to a weight of closer to 25 metric tons, this might still be within the capacity of the D–1, but pushing close to the possible upper limit.

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[43] Feoktistov, K. P. Znanie, seriya kosmonavtika i astronomiya, March 1980.

[44] Flight International, London, Mar. 30, 1967, p. 495.

[45] Grahn, S. and D. Oslender. Cosmos 146 and 154, London, Spaceflight, March 1980, vol. 22, pp. 121–123.

At the end of 1976 the D-1 was used to orbit two satellites in the Kosmos series which were recovered after only one orbit. Kosmos 881 and 882 were followed in 1978 and 1979 by two more pairs, Kosmos 997 and 998 and Kosmos 1100 and 1101. Trevor Williams suggested that these were reentry tests of winged vehicles.[46] Responding to this article, Grahn suggested that the two payloads were not identical.[47]

WITH PROBE ROCKET ADDED, D-1-e

During 1968, several Zond flights were made into deep space and around the Moon, some to return to Earth for successful recovery. These were identified as capable of carrying men. Of the known vehicles, only the D-1 with added stage should have the capacity to carry a crew on a circumlunar voyage. The pictures which ultimately were released of the Zond 4 through 8 series showed a craft which looked like a Soyuz without its work compartment but with a high gain antenna for long range communications. Because the Soyuz weighs about 6,570 kilograms, the Zond may be in the same range, but more probably lower such as 5,800 or even 5,300 kilograms saving weight on the work compartment but carrying added maneuvering fuel. Vick's version of D-1-e appears in figure 16 although the launch-escape tower depicted owes more to the ASTP vehicle than to that shown in a Soviet picture of what might well be a ground test of the system.

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[46] Williams, T. Soviet Re-entry Tests: A Winged Vehicle? London, Spaceflight, May 1980, vol. 22, pp. 213-214.

[47] Grahn, S. Double-Cosmos Launches, London, Spaceflight, Sept.-Oct. 1980, vol. 22, p. 329.

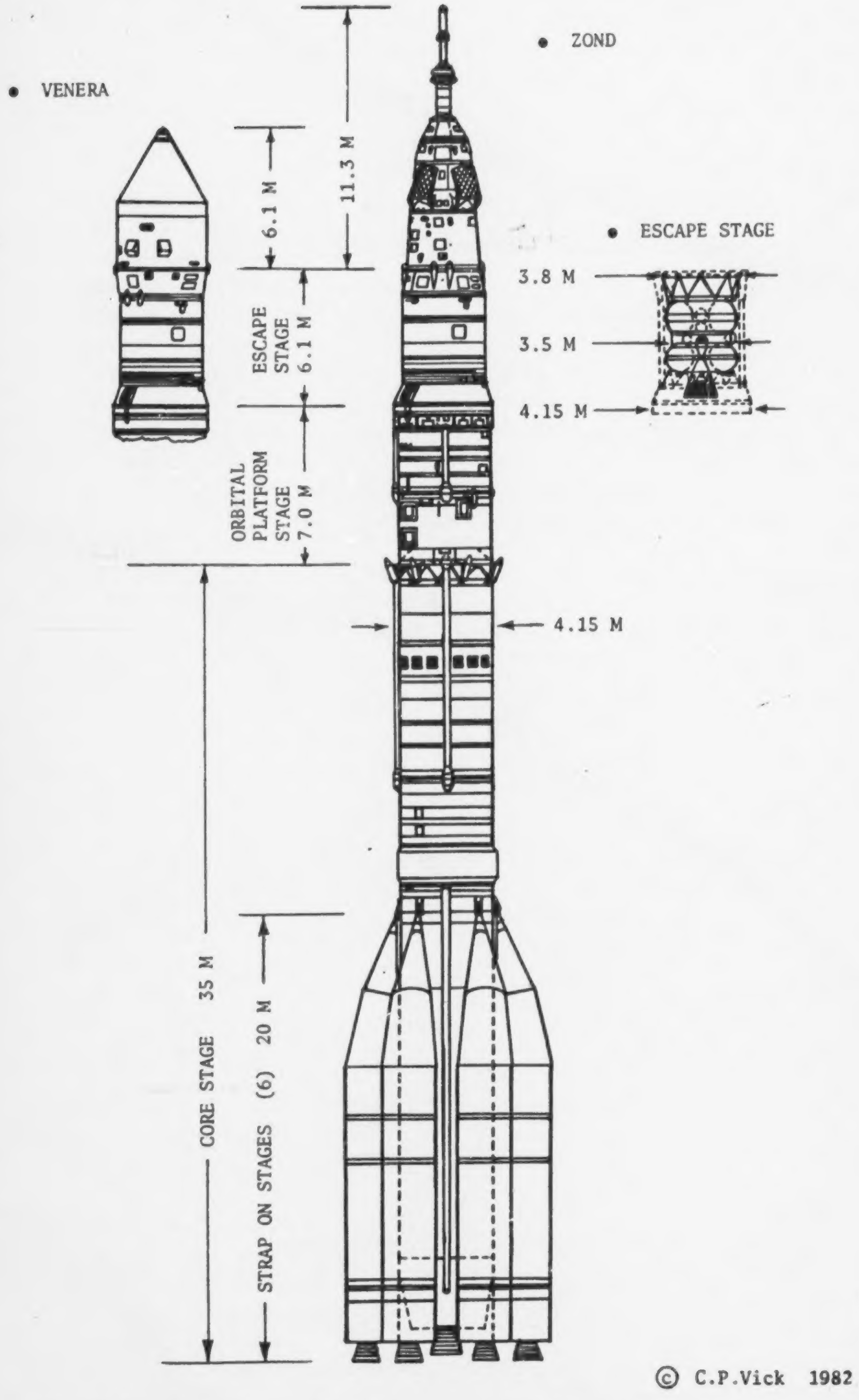
• ZOND
• VENERA
• ESCAPE STAGE
11.3 M
6.1 M
ESCAPE STAGE 6.1 M
ORBITAL PLATFORM STAGE 7.0 M
3.8 M
3.5 M
4.15 M
4.15 M
CORE STAGE 35 M
STRAP ON STAGES (6) 20 M
© C.P.Vick 1982

FIGURE 16. The nonmilitary vehicle with an added escape stage used for geosynchronous satellites and the current lunar and interplanetary spacecraft, D-1-e.

The D-1-e vehicle came into further use in 1969 for the unmanned lunar flights starting with Luna 15. Only occasionally have weights been announced. Luna 16 was listed as having landed 1,880 kilograms on the Moon, which is generally compatible with what one would expect. Since the Russians have announced an A-2-e payload of 1,640 kilograms sent to the vicinity of the Moon (Luna 11) and 1,180 kilograms sent to the vicinity of Venus, then a three-fold increase with use of the D-1-e would give 4,920 kilograms and 3,540 kilograms respectively. In fact the D-1-e likely does better. For lunar flights, it probably can carry a payload in the range of 4,820 to 6,500 kilograms (more likely between 5,300 and 5,800 kilograms); and for planetary flights to Venus or Mars, depending on the year it can probably deliver between 3,500 and 5,000 kilograms. These numbers square with the announced weights for Mars 2 and 3 at 4,650 kilograms. The D-1-e is now used to place communications payloads, in the Raduga, Ekran and Gorizont series, into 24-hour circular geosynchronous orbit close to a fixed position over the Equator.

A POSSIBLE D-1-m CONFIGURATION

In December 1970, Kosmos 382 was launched with only a routine announcement of its initial orbit, which ranged from 320 kilometers to 5,040 kilometers at an inclination of 51.6 degrees. Western observers noted that it had the same kind of man-related telemetry and frequencies as used for the Soyuz program and the other Kosmos flights starting with 379. But Kosmos 382 was different in its performance. It was maneuvered upward to 1,615 kilometers by 5,072 kilometers, and then again from 2,577 kilometers to 5,082 kilometers. In addition, on the last maneuver, the orbital plane was shifted to move the inclination from 51.6 degrees to 55.9 degrees. This was something that involved energy expenditures for a payload, presumably large enough to carry a human crew, that was beyond the capacity of any A-2 class vehicle. Consequently, it has been judged to be a version of the D-1. Since it used a platform launch technique, it left a spent carrier rocket and platform in the initial orbit reported by the Russians. Its subsequent multiple burns went beyond the performance of previous escape rockets. Hence one is led to the possibility of a D-1-m combination, with an improved maneuvering stage. Some people would suggest calling it a D-1-h, indicating that the upper stage not only maneuvered but demonstrated some special high performance.

If at some point the Russians bring in a new family of upper stages propelled by high energy fuels as the United States has done, we should see further increases in the lifting capacity of these A-2-e and A-2-m as well as D-1-e and D-1-m vehicles.

THE MILITARY SPACE LAUNCH VEHICLE ("F")

The cumbersome SS-6 Sapwood ICBM represented a beginning for the Soviet intercontinental missile stockpile, but its use of cryogenics, and awkward shape for potential silo use must have indicated fairly early that despite its continuing usefulness for space, it was not especially good for missile purposes, unless these were first strike.

In a 1967 article in Red Star, General Tolubko stated that these surface launches of the (Sapwood) took a long time to prepare and that later version rockets were smaller and placed in silos.[48]

As Soviet missile capabilities improved, they conducted more and more tests at the principal test site of Tyuratam which extended to the Kamchatka target areas, and then beyond to the mid-Pacific. These flights were often protested by the Japanese when target area closures were announced by the Russians. Photographs released by the U.S. Government of Soviet missile tracking ships in mid-Pacific and even of splashes of reentry bodies suggested that the United States was monitoring Soviet tests in the same way that Soviet ships monitor U.S missile tests. The Russians have always described these Pacific tests as further tests of carrier rockets, often signaling through variation in the language that new models were coming into the test program, rather than just continuation of earlier series. The observations made of the flights suggest they have definitely been tests of military missiles, not space carrier rockets as such. Every so often in the past, Soviet military leaders made specific reference to the high accuracy with which these tests delivered the "penultimate" stage of the carrier rockets to the assigned area.

As table 16 summarizes, the Western powers have assigned SS designators up through the SS-23 so far with four more unassigned, and there are NATO code names for most but not all of these, depending on whether they have been available on display or pictured in clear photographs. Of the longer range missiles, the SS-4, SS-5, and SS-6 have already been discussed in the context of their adaptation to space flight. At one time the SS-7 Saddler made up a large part of the Soviet missile inventory, but it was never put into a Moscow parade, and so far as can be judged was not adapted for space use. It was apparently a fairly modest capacity ICBM, which may have been the missile once shown in a rather blurred film clip from a Soviet movie and pictured on the cover of Missiles and Rockets magazine in the United States. The SS-8 Sasin was paraded in Moscow for a number of years, as the first Soviet ICBM ever given such public exposure. It seems never to have played a very prominent part in the inventory, but did become operational. According to U.S. Department of Defense testimony before Congress, the SS-11 replaced the SS-7 as the principal part of the Soviet ICBM inventory. Despite its extensive use, it has not been paraded in Moscow, and it does not seem to have come into space use. Having been hidden so carefully, it lacked any publicly known NATO code name until quite recently, but is now called Sego. It was also of relatively modest capacity.

Three other ICBM class missiles have been paraded in Moscow. These are the SS-9, SS-10, and SS-13. Taking them in reverse order, the SS-13 Savage is the technological equivalent of a Minuteman. But the Russians seem not to have favored solid propellant missiles for long range missile or space launch use. Some observers have said this is because their chemistry has not kept up with the same state of the art attained in the United States. In general, the Russians have moved from the early cryogenic systems to storable liquid propellants. Figure 17 shows the SS–9 and SS–10 along with a concept of SS–11. The SS–10 Scrag was first paraded in May 1965 and has not been seen since 1971. It was a long, cigar shaped three-stage rocket described by the Russians as "akin" to the Vostok launcher (which was then still 2 years away from its first public unveiling). The stages were joined by open truss sections. The Russians also hinted that this vehicle was capable of putting a bomb in orbit for delivery to any place on Earth. In November 1965, when it was paraded again, the Russians were a little defensive in their comments stressing it did not violate any treaty restrictions on use of space weapons because such agreements prohibited their use, not their production. Further, they said in a sense, every ICBM is a space weapon, anyway, as all such missiles fly through space, and their use is permitted under the terms of the space treaty.

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[48] Tolubko, V. F. Moscow, Krasnaya Zvezda, Nov. 18, 1967, p. 1A.

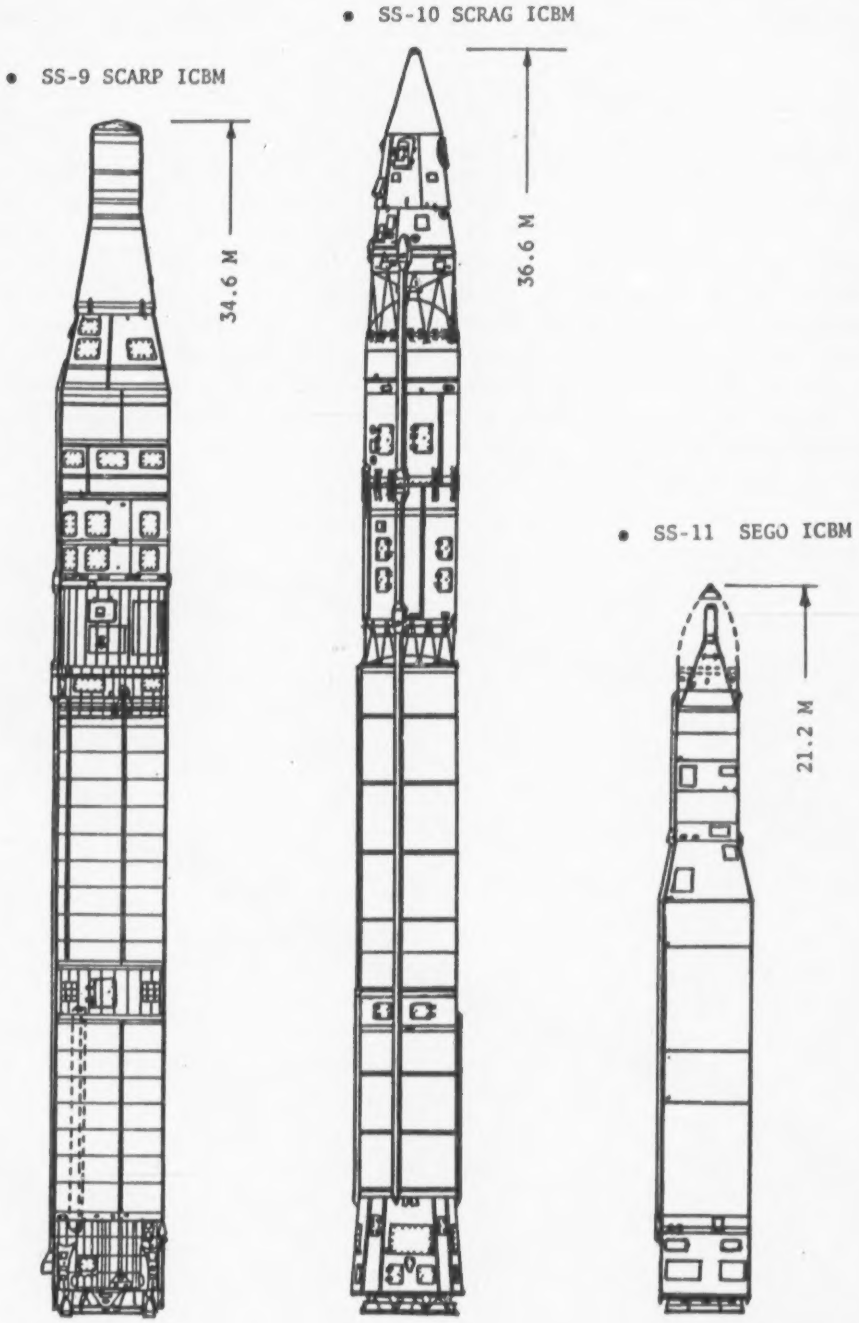
• SS-9 SCARP ICBM
34.6 M
• SS-10 SCRAG ICBM
36.6 M
• SS-11 SEGO ICBM
21.2 M

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FIGURE 17. Military missiles contributing to the F vehicle: (a) the SS-9, (b) the SS-10, (c) the SS-11 intercontinental ballistic missiles.

USE AS A WEAPONS CARRIER, F–1–r

When Soviet test flights of fractional orbit bombardment systems (FOBS, see volume III) began in 1966, unofficial Western observers wondered if they were seeing the SS–10 Scrag being flown. Later, the U.S. Department of Defense credited the FOBS flights to the SS–9 Scarp with added stages. Apparently the SS–10 Scrag never entered the operational inventory. It was paraded again in May 1966 and November 1966. The same brief description of its orbital use continued. However, when it was paraded in November 1967, no reference was made to an orbital capacity, and in the parade appeared for the first time the SS–9 Scarp. The Tass report on this new SS–9 was: "The last to appear were mammoth rockets each of which can deliver to target nuclear warheads of tremendous power. These rockets can be used for intercontinental and orbital launchings."[49]

The SS–9 has indeed become an important element in the Soviet arsenal, and in retrospect it is possible to trace its further extension to use in the space program as well, for missions closely allied with military functions, but not the more civilian and scientific part of the space program.

In December 1965, the Russians announced rocket tests which they called tests of "landing systems" with "some elements" falling in the Pacific (staging, not payloads), which fitted the operational pattern of FOBS flights which came later. In November 1966, General Dankevich associated orbital rockets with silo launches, and said these vehicles carried very large warheads.[50] Secretary Laird in the United States stated that the SS–9 Scarp was the carrier of the FOBS system.[51]

The SS–9 Scarp was paraded as a 33.2–35 meter long, bottle-shaped rocket, with a principal diameter of 3 meters. In the parade the warhead section was about 1.15 meters in diameter, then expanding into a cone to join the main 3 meter diameter cylinder. It is hard to tell precisely whether the SS–9 Scarp as paraded was a two or three stage vehicle. It may have been divided at about 17.5–19.7 meters up from the base, with perhaps another 10.4–8.5 meters making up the second stage, and 5.3 meters making up either a third stage with warhead or simply a warhead.

Since for 2 years the SS–10 Scrag was described as an orbital weapon, it is possible that the third stage of that vehicle was transferred to the SS–9 Scarp for a further version which has not been pictured or put on display. In some of its space uses, a fourth stage is also required, to account for the patterns of debris or expended rocket casings which can be observed in flight. Figure 18 shows a concept of the F–1–r configuration based on SS–9 and SS–10. An alternative final stage is also depicted.

Our interest in this rocket in the context of this report is as a military space payload carrier, the F–1–r or F–1–m. We cannot say what the whole assemblage looks like today. From parade views, we know the first stage differs from that of the A class vehicles. While the A class uses a core with four strap-on boosters, the F class first stage shows six fixed nozzles, and four swivel-mounted vehicles enclosed in protective covers, while a plate covers the center part of the base.

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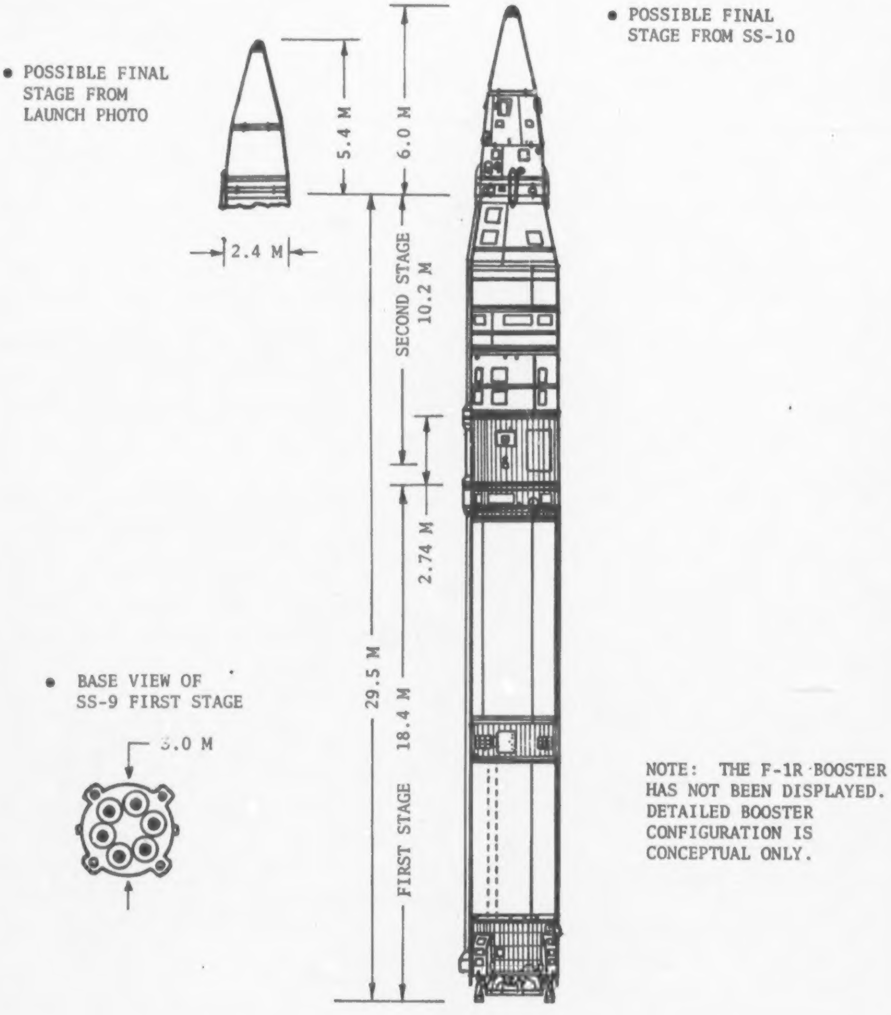
[49] Tass, Moscow, 0710 GMT, Nov. 7, 1967.

[50] Dankevich, P. E. Interview on Moscow Radio. 1430 GMT, Nov. 18, 1966.

[51] Laird, Melvin R. Fiscal Year 1971 Defense Program and Budget. Feb. 20, 1970, p. 103.



• POSSIBLE FINAL STAGE FROM LAUNCH PHOTO
2.4 M
5.4 M
6.0 M
• POSSIBLE FINAL STAGE FROM SS-10
SECOND STAGE 10.2 M
2.74 M
29.5 M
18.4 M
FIRST STAGE
• BASE VIEW OF SS-9 FIRST STAGE
3.0 M
NOTE: THE F-1R BOOSTER HAS NOT BEEN DISPLAYED. DETAILED BOOSTER CONFIGURATION IS CONCEPTUAL ONLY.

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FIGURE 18. The F-1-r configuration used for the FOBS program.

An article reviewing the use of the Scarp missile in its space-launcher role by Clark was published recently in Spaceflight.[52] The first known space use of the system was for FOBS tests, apparently in a four stage version. The first stage is suborbital. A carrier rocket stage, whether second stage or third stage is not clear, is abandoned in the initial orbit attained. The Royal Aircraft Establishment gives its dimensions as 8 meters long by 2.5 meters in diameter. In flight, a further change in orbit occurs, and this places an orbital platform in still another position. It is from this latter object that retrofire occurs (hence the designator "r" symbolizing the retrofire fourth stage) which drives the warhead back to Earth, while the rest of the orbiting hardware continues in space for at least a few more orbits.

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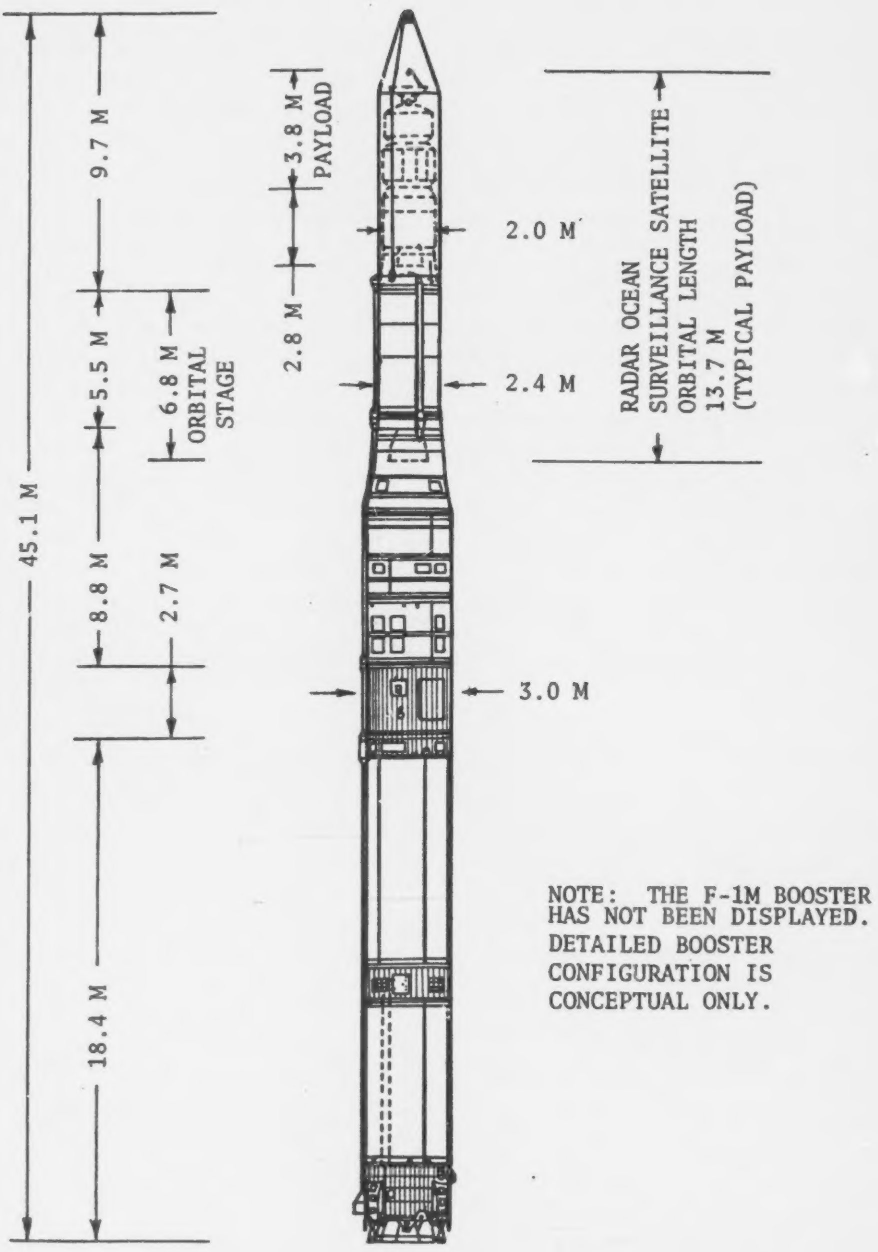
[52] Clark, Phillip S. The Scarp Program. Spaceflight. London, May 1981, vol. 23, pp. 147-152.

USE AS A MANEUVERING VEHICLE, F-1-m

The F class vehicles have now appeared in several other flight modes. The essential change in the hardware is the appearance of a fourth maneuvering stage which may be the outgrowth of work started in the Polet and Kosmos 102 and 125 programs. These can be labeled the F-1-m series, although there may be subtypes to fit the different flight modes which have been observed. A conceptual representation of the F-1 with one type of "m" stage and its associated payload is given in figure 19. All the F-1 class space payloads have been launched from Tyuratam. The FOBS flights were at an inclination of 49.5 degrees. The maneuvering flights relating to antisatellite (ASAT) tests started at an inclination of 62.2 degrees but, with the introduction of the C-1 to launch the target satellites from Plesetsk at 65.8 degrees, changed to 65 degrees at launch and incorporated a small change of plane prior to the interception.


45.1 M
9.7 M
5.5 M
8.8 M
18.4 M
6.8 M
ORBITAL
STAGE
2.7 M
3.8 M
PAYLOAD
2.8 M
2.0 M
2.4 M
3.0 M
RADAR OCEAN
SURVEILLANCE SATELLITE
ORBITAL LENGTH
13.7 M
(TYPICAL PAYLOAD)

NOTE: THE F-1M BOOSTER HAS NOT BEEN DISPLAYED. DETAILED BOOSTER CONFIGURATION IS CONCEPTUAL ONLY.

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FIGURE 19. The F-1-m configuration used for the ASAT program.

OTHER F-1 COMBINATIONS

The series of ocean surveillance satellites employing side-looking radar and powered by a small nuclear reactor is also launched from Tyuratam by the F-1. Clark considers the "m" stage to be used to perform the low-orbit injection as well as for raising the reactor to the higher orbit at the conclusion of the low-orbit operational phase.[53] It is possible that the other series of ocean surveillance satellites, with the presumed role of electronic intelligence gathering (Elint), use a different "m" stage to achieve a near-circular orbit with a 93.3 min. period and, later, to move away from this orbit at the end of their active phase. This has been designated as an F-1-x vehicle because of the uncertainty of the nature of the final stage.

Both of these classes of satellites fly at the 65 degrees inclination and make small orbital adjustments throughout the operational phase. In order to differentiate between these small stationkeeping maneuvers and the major maneuvers producing large changes in the orbital parameters, Perry suggested the adoption of the suffix "s" for sustainer when engines are used to maintain an orbit by neutralizing natural decay.[54] Even so, there is still the possibility that two different types of "s" stage are employed since that for the Elint satellites would not need to be so powerful as that for the radar type in which the stage which inserts the payload into the lower orbit remains attached to the payload throughout the operational phase.

THE IMPROVED F-2 VERSION

A new inclination of 76 degrees appeared with the launch from Plesetsk of Kosmos 921 in mid-1977. Two more Kosmos flights in the same year also flew at this inclination and are believed to have been vehicle tests of the F launcher from the northern cosmodrome. This inclination was not used again but a new series of launches at 82.5 degrees began in mid-1978. Kosmos 1076 and 1151 were identified as performing oceanographic research and had orbital periods of 97.8 min. as did the first launch of the series, Kosmos 1025. Kosmos 1045, with a period of a little more than 2 hours, was orbited by the same launch vehicle as the first two Soviet amateur radio satellites, RS1 and RS2.

Next to appear was a series of low orbit satellites at 82.3 degrees inclination which were recovered after missions lasting 2 weeks. Many of these were stated to be performing Earth resources missions and some were specifically identified as collecting data for the Priroda (Nature) Center. It is believed that all these missions are launched by a version of the F -vehicle with an improved upper stage which may be designated as F-2. Figure 20 is an attempt to guess at what the F-2 might look like if, indeed, such a variant does exist.

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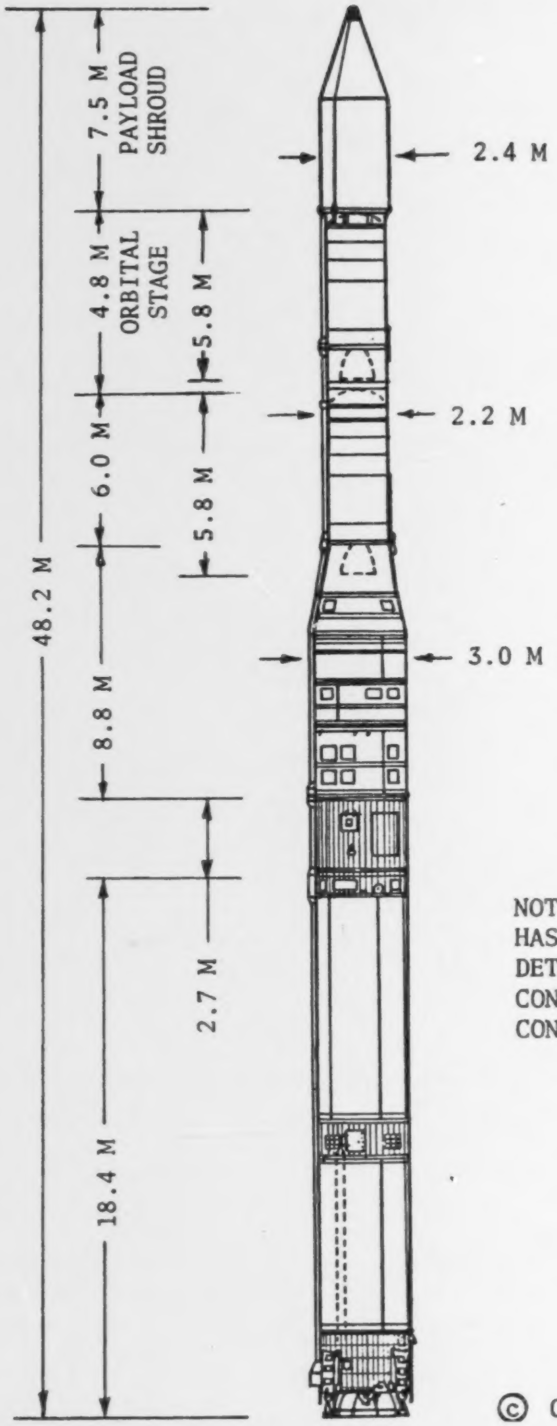
[53] Clark, P. S., op. cit.

[54] Perry, G. E., private communication to C. S. Sheldon, Oct. 9, 1980.


7.5 M
PAYLOAD SHROUD
2.4 M
4.8 M
ORBITAL STAGE
5.8 M
2.2 M
6.0 M
5.8 M
48.2 M
3.0 M
8.8 M
2.7 M
18.4 M

NOTE: THE F-2 BOOSTER
HAS NOT BEEN DISPLAYED.
DETAILED BOOSTER
CONFIGURATION IS
CONCEPTUAL ONLY.

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FIGURE 20. The F-2 vehicle with an improved performance. Opinions differ as to the existence of such a vehicle.

Commenting on the draft version of table 15, Clark expressed serious doubts about the wisdom of identifying the recoverable 82.3

degrees launches as F-2 on the grounds that, without new second and third stages, the F vehicle would be incapable of placing a 7,000 kilogram reconnaissance payload in orbit. Basing his reasoning on calculations and the report in Aviation Week and Space Technology to the effect that the new launcher is the two-stage missile with a new third orbital stage, he designates the vehicle as F-1-X rather than F-2.[55]

THE VERY HEAVY LAUNCH VEHICLE ("G")

Perhaps the most elusive space launch vehicle in the Soviet collection is their very heavy system. The need for such a system is highly compelling if the Russians have been serious in their interest in both manned lunar flight and later manned planetary flight. They have talked a great deal about orbital assembly of orbital stations and deep space-manned craft, but the actual use of orbital assembly has not kept pace with the talk and rumors of what they may be planning to do. Some of these possibilities will be discussed in other volumes of this study.

While orbital assembly is seen by Soviet space officials as the ultimate technique for many advanced missions, the availability of a large launch vehicle would serve Soviet interests at an earlier date in the same way the Saturn V was of use to the United States. Even when assembly is commonplace, putting up some heavy and complex components with a large launch vehicle has advantages.

Over the years, the Russians have taken some special pride in building large aircraft, hydroelectric dams, drag lines, battle tanks, and artillery. They have in the past stressed their leadership in high payload weights in space. One can imagine that a very large space launch vehicle would find a place in their hardware development. However, because they have treated all space propulsion details as sensitive information, they usually have waited some years after launch vehicles became operational before revealing details about them. This has been evident in the text of this chapter. Consequently, it is very difficult to find specific Soviet statements about a very large vehicle.

In the United States, however, there were statements by the most senior NASA officials through 1970 that such a Soviet very heavy lift vehicle was under development. Indeed, it was even described as having the general capacity of the Saturn V. Depending upon what assumptions one makes about upper stage efficiency, its lift capacity for several missions can be variously estimated. If it was originally intended to fly during the late 1960's, it can be speculated that perhaps some or all of the stages of D-1-e vehicle related to Proton, Zond, deep space, and Salyut payloads, would represent a shortcut way to attain an earlier operational capability. This would be akin to the U.S. use of the S-IVB stage on Saturn V or the Centaur stage on Titan III. Since the D-1-e vehicle does not demonstrate the kind of lifting efficiency associated with high energy fuels, it can be speculated the G-1-e heavy lift vehicle will also fall short of its full potential in early use. The NASA estimates about the Soviet vehicle put the first stage thrust in the range of 4.5 to 6.35 thousand metric tons, compared with 3.4 thousand metric tons of the Saturn V. But without high energy fuels, that might mean a capacity to deliver about the same 45,500 kilograms to the vicinity of the Moon which a Saturn V typically will send.

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[55] Clark, P. S., private communication to C. S. Sheldon, February 1981.

How reliable can such estimates be? That is hard to say for a vehicle which the Russians have not discussed in specific terms, and which in any case is too big to be paraded. But since the "national technical means" which are used to count Soviet missile silos and slight differences in their dimensions are freely cited by Secretaries of Defense, one has to assume that this Nation should have a fair idea of the scope of work associated with such a postulated large vehicle.

The Russians themselves have thoroughly obscured the issue of whether in fact such a vehicle exists. Some have praised the economy of orbital assembly over direct flights to the Moon with a big vehicle. On November 12, 1965 Cosmonaut Nikolayev stated in a Soviet radio interview that studies were underway to see whether manned flights into deep space should be solely through orbital assembly or also through use of a large vehicle for direct flights. By July 1966, a Czech commentator, Jan Petranek, was talking in terms of a 100,000-kilogram-payload ship.[56] In March 1967, General Kamanin, the leader of the cosmonaut corps was predicting flights to the Moon of payloads in the 60,000 to 70,000 kilogram range.[57] This might have meant through orbital assembly, but if based upon use of high energy fuel in upper stages would scale well with the 4.5 to 6.35 thousand metric ton thrust first stage for the G class vehicles, since a Saturn V at 3.4 thousand metric tons thrust would deliver 45,500 kilograms on a similar mission.

One of the most specific forecasts of a very large Soviet vehicle was written by Karel Pacner of Czechoslovakia in the October 4, 1967 issue of the Prague magazine Student, in which he specifically credited Cosmonaut Popovich and General Kamanin as saying the very large vehicle was under preparation, that is, a vehicle well ahead of the D class. By October 1967, Cosmonaut Feoktistov, who as a senior official of the space design bureau, was quoted in Pravda as forecasting deep space flights using both the approach of Earth orbital assembly and direct from the surface of the Earth with (large) vehicles.[58] In March 1968 at Frankfurt, Leonid Sedov, the important space academician, stated there were now larger rockets in existence which were used exclusively for space, as opposed to adapted military rockets, and that these could support flights to the Moon and planets. The rocket required for landing on the Moon already existed, he said.[59]

Rumors and cosmonaut predictions of a manned lunar landing by the end of 1969 were prevalent in the first half of that year, and could reasonably have been supported only by flights of a large vehicle. It is hard to conclude the Russians were really ready for such a mission on the basis of public evidence, although some surprising development might have made if feasible. Alternatively, the Soviet predictions of that spring may have garbled plans for manned orbital flight around the Moon and also the automated return to Earth of lunar samples gathered by remotely controlled devices, rather than referring realistically to manned lunar landings that early. In any case, no successful flights of the big vehicle were accomplished, and the American press by early fall was repeating stories of uncertain origin that there had been a failure (or failures) of the big vehicle. It is obvious that hopes for any manned operations, whatever the missions, in 1969 were not met, including any time-competitive flight to rival Apollo 11, or any followon American flight if Apollo 11 had failed.

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[56] Petranek, Jan, quoted on Prague Radio, 1530 GMT, July 21, 1966.
[57] Kamanin, N., quoted on Warsaw Radio, 1900 GMT, Mar. 9, 1967.
[58] Quoted by Moscow Radio, 0300 GMT, Oct. 3, 1967.
[59] Frankfurt Radio, 2020 GMT, Mar. 20, 1968.

The next Soviet reference to a potentially large vehicle was by Academician Boris Petrov in August 1969, that a new type of vehicle would be used to place a large unmanned space station in orbit, that it was not necessary to send men to the Moon when automatic devices could perform the mission of bringing home rocks. He said that up to four Soyuz craft could then dock with this large new space station. While talking of ultimate flight to the Moon, he claimed that Luna 15 could not carry a man, but that the Zond class could; and further that some flights would be direct to the Moon.[60]

The most recent official U.S. statement on the large vehicle comes in the Department of Defense's booklet, Soviet Military Power.[61] Commenting on apparent Soviet interest in developing an improved ASAT it says:

> A very large space booster similar in performance to the Apollo program's Saturn V is under development and will have the capability to launch very heavy payloads into orbit, including even larger and more capable laser weapons. This booster is estimated to have six-to-seven times the launch weight capability of the Space Shuttle.
>
> . . . The new booster will be capable of putting very large permanently manned space stations into orbit. . . .

From these many speculative statements and inferences of the logic of how to achieve missions the Russians have repeatedly claimed were encompassed within their interest, it seems possible to postulate at least two versions of the large vehicle: One would be G–1–e, intended for flight to the Moon; the other would be the G–1, intended for launching a space station core into Earth orbit. Later versions might substitute high energy fuel upper stages enhancing the performance over the levels estimated to be similar to the Saturn V.

One can speculate that any direct flight to the Moon with men would be beyond the capability of the G–1–e as described, since the Saturn V could not do this. Either a rendezvous operation would be required, or the G–1–e would have to be uprated with high energy fuels, to make it the equivalent of the one-time NASA design concept called Nova. Some of these possibilities will be explored in further details in a later volume.

Meanwhile, what has happened to the class G vehicle? Some Western observers doubt that it ever existed. This seems unlikely, considering the need and the NASA official testimony. Charles P. Vick has even drafted a book about this yet unobserved vehicle with his findings summarized in Spaceflight magazine.[62] Vick has made extensive studies of the Landsat pictures of the Tyuratam launch area, using pictures taken in several different wavelengths, and he is convinced he can pick out two very large launch pads and a major assembly building which support the G class vehicles. While his studies have tested a variety of hypotheses for various structures which might represent the design of the G class vehicles, it seems the data in the public domain are too scarce to come up with any real insight. Assuming that the vehicle uses some form of clustering as is true of both United States and Soviet vehicles of large size, and further assuming the configuration is anything like the A class vehicles, then the basic stages without escape stage and payload may measure on the order of 80 meters tall and with a base measure of 17 meters, or if there are fins, 21 meters. No one should be misled into thinking that these dimensions are the actual ones; rather, they merely show in terms of tankage how big a vehicle of the A configuration would be if the thrust were around 5.4 thousand metric tons. A 1977 Soviet publication depicted a launch facility with a turning tower more than 100 meters high which could be used to service such a giant vehicle.[63] This moves on bogies round circular railroad tracks.

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[60] Tokyo Kyodo, 0505 GMT, Aug. 20, 1969.

[61] Soviet Military Power, Washington, D.C., U.S. Department of Defense, 1981, pp. 79–80.

Vick used this as the basis for a design concept and matched the service levels with dimensions and estimated performance of a G vehicle and came up with a facility with three flame pits. Vick's studies were used by Salamander Books for their Illustrated Encyclopedia of Space Technology. A colored drawing of his speculative appearance of the G vehicle is to be found on the foldout pages depicting the launch vehicles of all nations and agencies.[64] Figure 21 is a similar representation along with a cutaway showing probable layout of the tankage. The U.S. Saturn is shown to provide an indication of relative size. Figure 22 shows what the facility might look like when the booster is in place prior to launch. These conceptual drawings are included in the absence of anything more definitive in the open literature, although it must be emphasized that the true appearance may, one day, turn out to be quite different.

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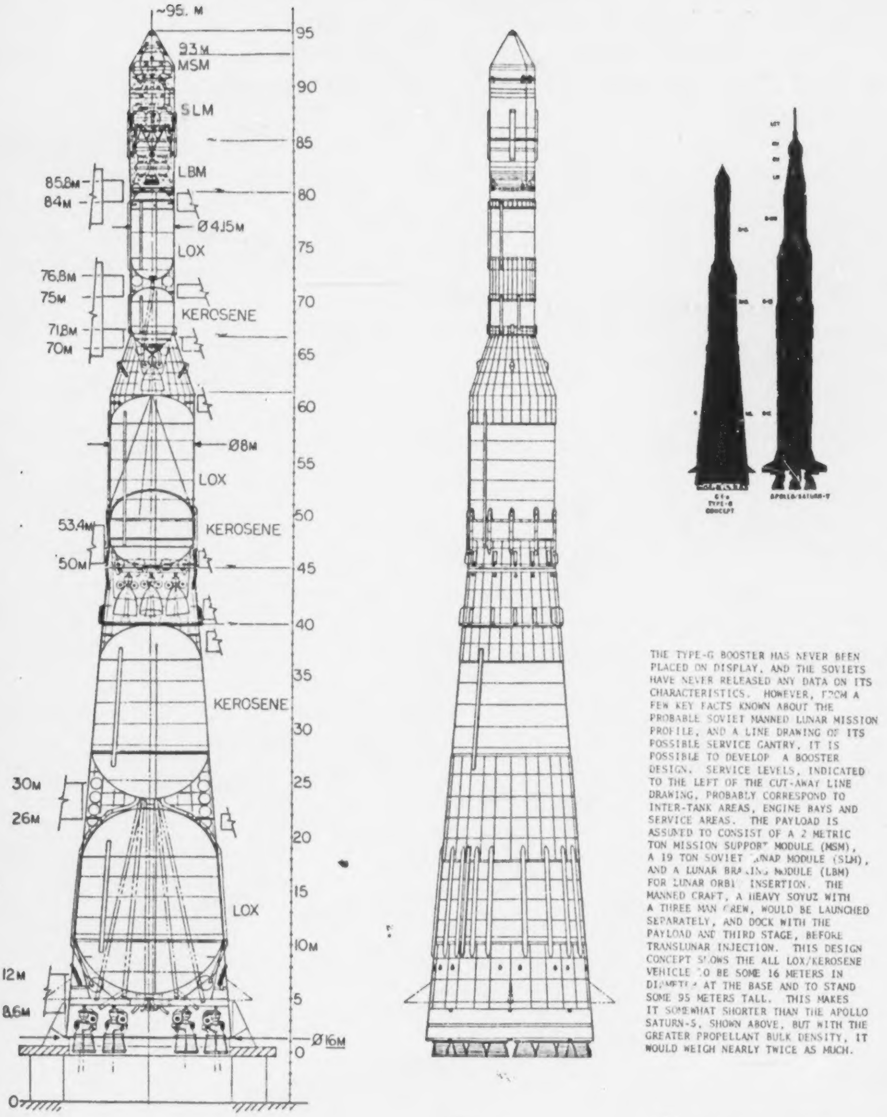
[62] Vick, Charles P. The Soviet Super Boosters—2 London, Spaceflight, March 1974, pp. 94-104.

[63] Vol'skiy, A. P., et al. Kosmodrom, Moscow, Veyenizdat Publishing House, 1977, p. 126, fig. 4.23.

[64] The Illustrated Encyclopedia of Space Technology, London, Salamander Books, Ltd., 1981, pp. 52-53.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THE TYPE-G BOOSTER HAS NEVER BEEN PLACED ON DISPLAY, AND THE SOVIETS HAVE NEVER RELEASED ANY DATA ON ITS CHARACTERISTICS. HOWEVER, FROM A FEW KEY FACTS KNOWN ABOUT THE PROBABLE SOVIET MANNED LUNAR MISSION PROFILE, AND A LINE DRAWING OF ITS POSSIBLE SERVICE GANTRY, IT IS POSSIBLE TO DEVELOP A BOOSTER DESIGN. SERVICE LEVELS, INDICATED TO THE LEFT OF THE CUT-AWAY LINE DRAWING, PROBABLY CORRESPOND TO INTER-TANK AREAS, ENGINE BAYS AND SERVICE AREAS. THE PAYLOAD IS ASSUMED TO CONSIST OF A 2 METRIC TON MISSION SUPPORT MODULE (MSM), A 19 TON SOVIET LUNAR MODULE (SLM), AND A LUNAR BRAKING MODULE (LBM) FOR LUNAR ORBIT INSERTION. THE MANNED CRAFT, A HEAVY SOYUZ WITH A THREE MAN CREW, WOULD BE LAUNCHED SEPARATELY, AND DOCK WITH THE PAYLOAD AND THIRD STAGE, BEFORE TRANSLUNAR INJECTION. THIS DESIGN CONCEPT SHOWS THE ALL LOX/KEROSENE VEHICLE TO BE SOME 16 METERS IN DIAMETER AT THE BASE AND TO STAND SOME 95 METERS TALL. THIS MAKES IT SOMEWHAT SHORTER THAN THE APOLLO SATURN-5, SHOWN ABOVE, BUT WITH THE GREATER PROPELLANT BULK DENSITY, IT WOULD WEIGH NEARLY TWICE AS MUCH.

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FIGURE 21. The very heavy launch vehicle, G. This has not yet flown successfully.

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Aviation Week has carried a number of times the apparent dates or periods that launch attempts were made with the G class vehicle, all of which failed.[65] If it is true that there have been three failures since the first attempt in 1969, this must have been very disappointing to the program managers. Now, more than 10 years later, a successful flight has not been seen. The program may be as much as 22 years old, and presumably a very heavy investment has been made in assembly, testing, and launch facilities as well as the cost of developing the flight articles. The investment is perhaps almost too much to write off, and future parts of the program depend upon successful development.

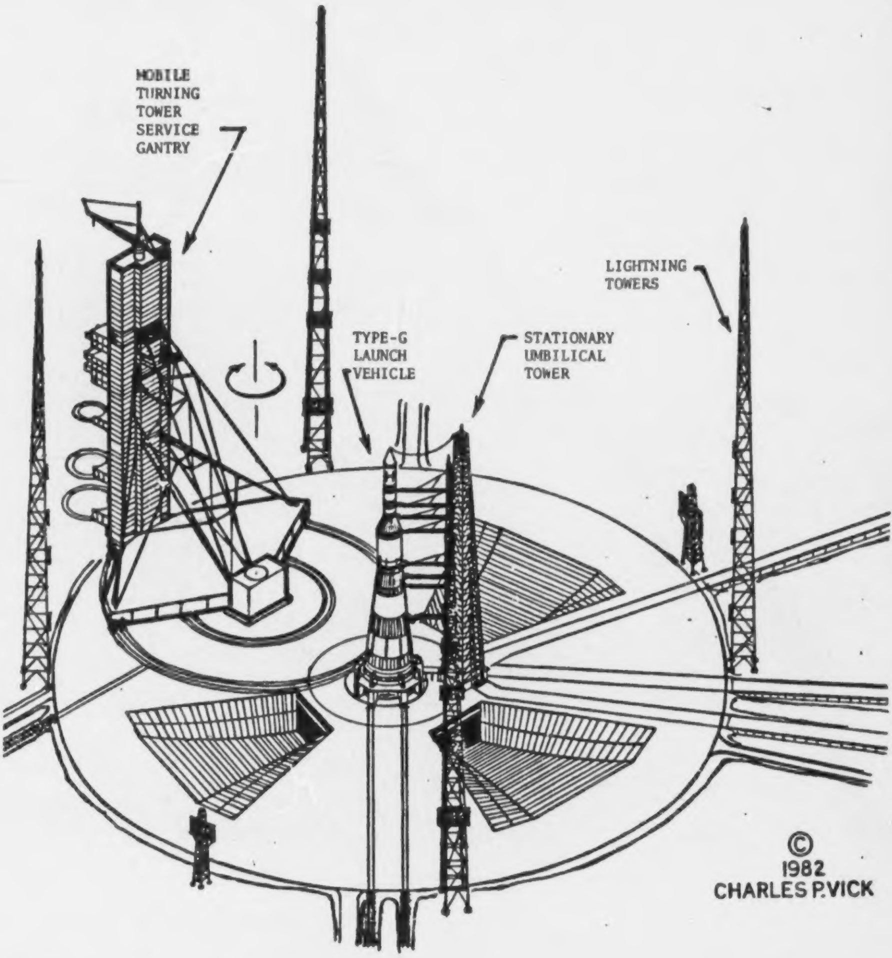
MOBILE TURNING TOWER SERVICE GANTRY
LIGHTNING TOWERS
TYPE-G LAUNCH VEHICLE
STATIONARY UMBILICAL TOWER
© 1982 CHARLES P.VICK

FIGURE 22. C. P. Vick's concept of what the G vehicle facility at Tyuratam might look like. (See text for details of basis for drawing.)

This concludes the discussion of launch vehicles which either have been used successfully or there are strong grounds for suspecting have been tested for space purposes. Predictions for the future will be considered in another chapter. Some Western analysts have postulated a number of additional Soviet space launch vehicles, including one midway between the D and G vehicle sizes,[66] but this chapter has not speculated on vehicles which have not appeared in some form, as even dealing with the "known" vehicles has proven difficult enough.

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[65] Aviation Week, New York, Mar. 17, 1975, p. 71, summarized these failures.

VERTICAL ROCKET PROBES

The record of major Soviet vertical sounding rockets is incomplete but even those that are known show they have made a significant contribution to the total program and to the orbital flights which followed the earlier ones. Most of the major sounding rockets have been launched from the Volgagrad Station at Kapustin Yar. Smaller sounding rockets and meteorological rockets have been launched not only from there but at such places as Kheys (Hays) Island, on Soviet scientific research ships at sea, and even in Antarctica.

Figure 23 shows the evolution of the sounding rockets from the early V-1 derivatives through the SS-5 used for the later Interkosmos Vertikal payloads.

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[66] For example, see: Stine, G. Harry. Some Strange Things Happened at Baykonur. Analog Science Fiction/Science Fact, 1970, pp. 104-120.

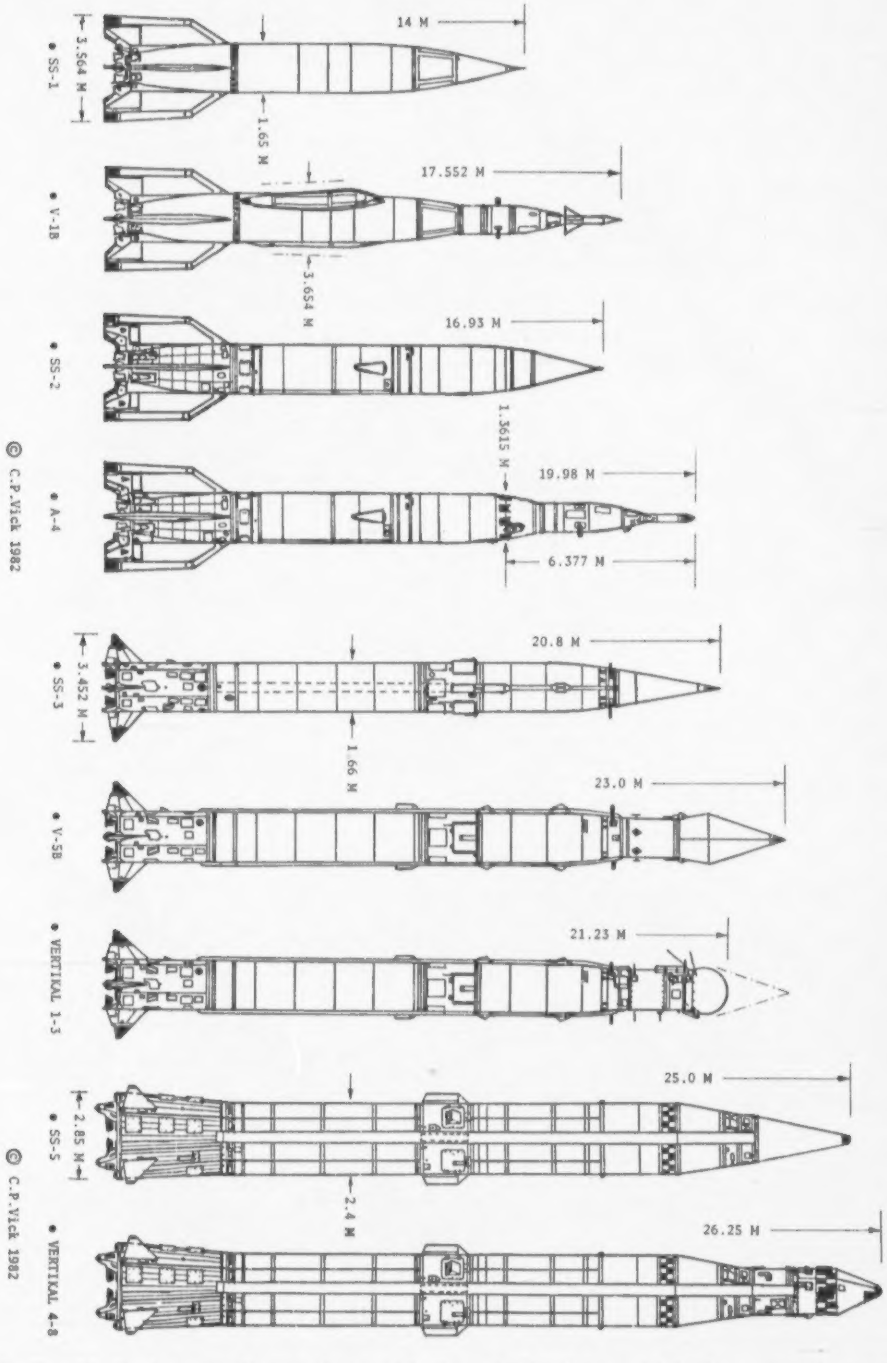
14 M
3.564 M
• SS-1
1.65 M
17.552 M
• V-1B
3.654 M
16.93 M
• SS-2
1.3615 M
19.98 M
• A-4
6.377 M
© C.P.Vick 1982
20.8 M
3.452 M
• SS-3
1.66 M
23.0 M
• V-5B
21.23 M
• VERTIKAL 1-3
25.0 M
2.85 M
• SS-5
2.4 M
26.25 M
• VERTIKAL 4-8
© C.P.Vick 1982

FIGURE 23. Soviet sounding rockets with the missiles from which they were derived.

TRACKING AND OTHER GROUND SUPPORT

COMMUNICATIONS NEEDS

Space operations require extensive support from Earth, including not only a launch pad with its associated assembly and checkout equipment, but also down range guidance and command, tracking, and other communications links. After the payload is in orbit, then tracking is useful for keeping posted on it and on all other objects in space, and for commands to the payload and receipt of data gathered or observed by the payload.

The Soviet Union may have started its space program with a curious mixture of very ambitious and comprehensive plans for use of large vehicles which could perform many missions in Earth orbit and beyond, combined with minimal support on the ground in terms of varieties of hardware, limited number of pads, and minimal communications links.

It is very likely that the early launch guidance was primarily by radio, radar and optical means because of the pattern of flying down the same corridor repetitively from Tyuratam; indeed this may still be true for many space launches, simply with more radio and theodolite tracking stations being added along additional corridors. This is suggested by the fact that vehicles which almost certainly must come from different launch pads, added when new types of vehicles were added, fly on inclinations that vary from the earlier standard ones only by an amount compatible with passing near some down range tracking points in about the same relationship as vehicles launched from the original pads.

Minimal ground support will permit the start of a program, but as needs to exploit the potential of space for science and applications grow, then more is required in Earth-based facilities.

EARTH ORBITAL TRACKING IN THE U.S.S.R.

Soviet public statements about their tracking capabilities for the early years made particular reference to optical tracking facilities. These were in many parts of their own country. They also encouraged observers in Soviet bloc countries to send reports of observations to Moscow. Some of the equipment was relatively simple; only a few more advanced telescope systems were pictured, with no indication of how many of these better systems there were.

Science journalist Lloyd Mallan testified that he was shown the tracking camera on the roof of the Sternberg Astronomical Institute and found it to be a modified Red Air Force aerial camera with wide-angle f/2.5 lens.[67] Professor Alla Masevic, now chairman of the U.S.S.R. Academy of Sciences Astronomical Council, had told him that the equipment was used at every key satellite tracking station in the Soviet Union. In visits to five or more stations spread over some 1,000 miles, Mallan verified this statement. However, his general conclusion that the United States was immeasurably far ahead in space technology at that time[68] should not be accepted unreservedly. Mallan's photograph of the camera, published in his article and reprinted in the record, identifies it as the NAFA 3c/25. Two different views appear in a book by Desmond King-Hele.[69] In discussing the performance of such an instrument, in comparison with the Baker-Nunn cameras developed by the Smithsonian Astrophysical Observatory, King-Hele concludes that the accuracy of about 0.001 degree in direction and about 0.003 seconds in time was almost as good.[70]

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[67] Hearings before the Committee on Science and Astronautics and Special Subcommittee on Lunik probe, House of Representatives, 86th Cong. 1st sess., pp. 21-22, May 11, 1959.

[68] Mallan, Lloyd, The Big Red Lie, True, Fawcett, May 1959.

Even with Soviet reticence in discussing more than optical tracking there were Western reports of a network consisting of a master station and 12 others equipped with receivers to measure Doppler shifts in radio signals, tracking radars, and phototheodolites, transmitting data to a central computation center.[71] Four such stations were revealed as to location by the Russians in 1964 in a COSPAR report.[72] The Tass announcement of the launch of Sputnik 3 stated that the satellite was equipped with special transmitting installations which enable the coordinates of its trajectory to be measured.[73] In the following year, Tass reports of the impact of Luna 2 on the Moon's surface referred to an automatic measuring system for precise determination of the trajectory. From the technical information released in connection with ASTP, it is known that an S-band (217–219 GHz) radar transponder was installed on the Soyuz spacecraft. This frequency range has been used by tracking radars since World War II. Satellites in the small-kosmos and Interkosmos series have standardized conical antennae of sizes suitable for these microwave frequencies. Therefore, one can conclude that S-band radars have been used for orbit determination from the outset.

The first official and more extensive listing came in connection with the Apollo-Soyuz-Test-Project in 1975. This included the following seven land bases: Yevpatoriya, Tbilisi, Dzhusaly, Kolpashevo, Ulan-Ude, Ussuriyisk, and Petropavlovsk.[74] More likely than not, there are other stations to meet the needs of particular programs.

Preparations for the launch of the second Indian satellite, Bhaskara, in 1979 produced an indication of another ground station, near to Moscow, at Medvezhyie Ozera or Bears Lake.[75] Indian experts were reported to be given the opportunity of using this facility, free of charge, for receiving information and controlling the satellite during the first phase of its mission. A similar announcement, following the launch of Bhaskara 2, in 1981, defined the duration of this period as being from 15 to 20 days.[76] The Indian space research center at Sriharikota, Moscow, and the monitoring center at Bears Lake were to be connected by telex and direct telephone lines.[77]

In 1976, specialists from the Soviet Union, Hungary, Poland, the German Democratic Republic, and Czechoslovakia held an international school on laser observation of Earth satellites in the Crimea at one of the tracking stations where a new device had been assembled to determine the distance of a satellite by sending a pulse of laser radiation to the satellite and picking up its reflection.[78] From a knowledge of the elapsed time, between transmission and reception of the pulse, and the velocity of electromagnetic radiation, corrected for atmospheric conditions along the path, it is possible to determine the distance from source to reflector with great accuracy. Moreover, the simultaneous determination of azimuth and elevation fixes the satellite's position in the three-dimensional polar coordinates. However, such a method is limited for use with satellites equipped with corner-reflectors, which return the incident radiation along the line of incidence in the manner of the "catseye" reflectors used for road markings, and at times of clear skies. The report went on to say that similar installations had been handed over to Poland and Bolivia and were in preparation for India and Cuba. Laser installations in foreign countries are dealt with in the section which follows.

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[69] King-Hele, Desmond, Observing Earth Satellites, plate 6, London, Macmillan, 1966.
[70] Ibid., p. 75.
[71] Aviation Week, New York, Jan. 26, 1969, p. 26.
[72] COSPAR Bulletin No. 18, Paris, April 1964, pp. 10–11.
[73] Tass, 1018 GMT, May 15, 1958, p. 71.
[74] Aviation Week, New York, May 5, 1975, pp. 42–43.
[75] Tass in Russian for abroad, 1916 GMT, Nov. 3, 1978.
[76] New Delhi Home Service in English, 1530 GMT, Nov. 20, 1981.
[77] Moscow Radio in English for S. and S.E. Asia, 1400 and 1500 GMT, May 15, 1979.

In addition to tracking stations tied to specific programs, the Russians have a space defense system, akin to the facilities which feed data to Norad on this continent. There have been frequent references in the Western press to their ABM defense system, which of necessity is not only a missile launching system, but is also an elaborate tracking system, built around large arrays of radar referred to as Hen House. Any system which tracks long range strategic missiles also tracks space objects crossing Soviet territory or its approaches, regardless of nationality and absence of active signal emissions.

Because of the size of the Soviet Union in geographic terms, stretching as it does to a width close to two and a half times that of the continental contiguous United States, the domestic space tracking network does a better job of coverage than would a U.S. domestic system. But any worldwide tracking capability must extend beyond the political borders of any single nation.

FOREIGN TRACKING STATIONS

From the time of Vanguard on, the United States developed bilateral agreements with other nations to permit the establishment of tracking stations in all parts of the world, especially north and south through the Americas, essential to coverage of the satellites using Minitrack. Then a similar system was developed for Project Mercury in an equatorial belt around the Earth. This was expanded and supported Gemini and the Earth orbital operations of Apollo.

The Soviet Union either did not feel the same need for such complete coverage of its flights, being content to pick up recorded data as the flights went over their own territory, or perhaps they were reluctant to negotiate pacts with other countries which would expose the details of their data collection in the same open manner as the NASA program of the United States.

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[78] Moscow Radio Home Service, 0200 GMT, Nov. 2, 1976.

Hence, in a much more limited way they developed only a few largely unpublicized tracking stations in other countries, mostly places with a political climate favorable to the U.S.S.R. In December 1967, Tass referred to Soviet stations in the United Arab Republic (presumably Helwan), Mali, and "other" countries.[79] By April 1968, Guinea in West Africa was also named.[80] By October 1968, reference was made to a station in Cuba.[81] In February 1970, reference was made to a second station in the U.A.R., this one in Aswan.[82] In 1971, they added one in Fort Lamy, Chad.[83] From time to time there have been rumors and reports that the Russians put out feelers that they might like to establish tracking stations in such countries as Indonesia, Australia, and Chile. It is believed tracking is done at Khartoum in the Sudan, Afgoi in Somali, Kerguelen (South Indian Ocean) and Mirnyy (Antarctica).

The laser tracking program referred to in the previous section was named as the Great Arc project in a Czechoslovakian broadcast in 1977.[84] The report claimed that Czechoslovakian scientists and technicians had participated in the development and production of laser radars which operate in several socialist countries, in Egypt, Bolivia and India. Later that year a Cuban broadcast reported that a powerful laser tracking station, built by experts of the Soviet Union, Czechoslovakia, Cuba and other Interkosmos countries, was being erected at the satellite observation station near Santiago de Cuba.[85] Clear skies over the island virtually throughout the year was given as the reason for the choice of Cuba as the site for the installation. In 1980, Professor Alla Masevich visited the station during a visit to Cuba.[86]

1980 saw the addition of Latvia to the network of stations making regular observations of artificial satellites using a laser rangefinder.[87] An accuracy of 1 or 2 meters in the distance of satellites several thousand miles from the Earth was claimed. The purpose of the work was stated to be to monitor irregularities in the Earth's rotation, the shifting of the Poles, continental drift and geodetic data. While these are all laudable scientific objectives accurate geodetic data is essential for the perfection of delivery systems of intercontinental ballistic missiles (ICBM's) to their targets.

The Polish contribution to geodesy under the aegis of the Interkosmos program was described in an article by Dr. Olgierd Wolczek.[88] Observations of the orbits of artificial satellites made by the Agricultural Academy in Olsztyn, the Adam Mickiewicz Astronomical Observatory in Poznan, and the Institute of Geophysics in Borowicz were used to study the effect upon the orbits of the Earth's gravitational field, luni-solar gravitational fields, solar radiation pressure and drag in the upper layers of the atmosphere.

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[79] Tass, 0755 GMT, Dec. 7, 1967.

[80] Moscow Radio, 1800 GMT, Apr. 13, 1978.

[81] Granma, Havana, Oct. 19, 1968, p. 6.

[82] Tass, 1940 GMT, Feb. 8, 1970.

[83] Tass, 1719 GMT, Feb. 8, 1972.

[84] CTK in English, 2112 GMT, Feb. 15, 1977.

[85] ADN, 0603 GMT, June 7, 1977.

[86] Havana Home Service, 1100 GMT, Jan. 16, 1980.

[87] Tass in Russian for abroad, 0753 GMT, Mar. 10, 1980.

[88] Wolczek, O. Poland in the Intercosmos Program. Spaceflight, vol. 22, May 1980, pp. 190–192.

To this end, a laser-measuring apparatus was installed at Borowicz in 1975 giving an accuracy of 1.2 meters.

Coincident with the introduction of the Automatic General Purpose Orbital Station (AUOS) type of Interkosmos satellites, a unified telemetric system was established with ground stations in various Interkosmos countries. One of the first to be established was that at Havana in Cuba.[89] This was closely followed, early in 1977 by the inauguration of the first stage of the radio-telemetric station built at Stara Zagora in Bulgaria.[90] The memory systems which were constructed at Plovdiv and Stara Zagora, were the Bulgarian contribution to the project. The station was later identified as the Yuriy Gagarin Observatory.[91]

The Czechoslovakian station is located at Panska Ves in Northern Bohemia and is described as the ionospheric observatory of the Geophysical Institute of the Czechoslovak Academy of Sciences.[92] This station was responsible for controlling the Magion satellite with which it made contact four times daily.[93] The station had its last contact with Magion on September 10, 1981, just before it decayed after nearly 3 years in orbit and making more than 16,000 orbits.

A Polish report in 1978 instanced plans to construct a satellite data reception station in Cracow designed to collect information from meteorological satellites.[94]

SEA-BASED SUPPORT

Because of Soviet reluctance to become too dependent upon foreign land-based stations, or perhaps because not all nations approached were willing to be hosts, the Soviet Union has put considerable emphasis upon developing a sea-based support system. These consist of several classes of ships. One group operates in the mid-Pacific, and has been pictured in Western magazines and books. These are fairly impressive looking, loaded down with radomes and many specialized antennas and theodolites. They serve both to record missile tests, in the area where the dummy warhead is to splash; or in sight of the orbital path of spacecraft overflying the Pacific, usually for their initial revolution.

Other less well-equipped ships in comparison with the missile trackers have for some years operated in the tropical Atlantic and the Mediterranean along the path of orbital flights. Such ships would put into various ports in these parts of the world for supplies and crew rest, and when they left port it was usually an indication that new space launches were pending.

By noting what tracking ships are registered by the Russians as civilian type vessels, and which are treated as naval ships, it appears that the Pacific missile tracking ships whose pictures have been published after being photographed at sea by U.S. aircraft, are under the operational control of Soviet military authorities.

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[89] Moscow Radio Home Service, 2030 GMT, Oct. 29, 1976.
[90] BTA in English, 1450 GMT, Jan. 25, 1977.
[91] Tass in Russian for abroad, 1138 GMT, Apr. 8, 1977.
[92] Prague Home Service, 2250 GMT, Nov. 14, 1978.
[93] Prague Home Service, 1200 GMT, Nov. 15, 1978.
[94] PAP in English, 1306 GMT, July 5, 1978.

By contrast, the ships seen in the Atlantic and Mediterranean have now been identified as operating for the Soviet Academy of Sciences. Where once these ships were merchant vessels with only a minimum of modifications in appearance to serve the space program, now there has been a marked upgrading and even the development of highly sophisticated big ships with considerable communications equipment on board. In December 1967, the science ships were identified as the *Dolinsk, Bezhitsa, Ristna, Aksay, Morzhovets, Kegostrov, Nevel, Borovichi,* and *Kosmonavt Vladimir Komarov.*[95] Since that time virtually all of these ships have been named by the Russians as being in particular regions to support certain space flights, especially in the Atlantic, but also in the Indian Ocean. An account of the return to Earth from Salyut 5 of the Soyuz 21 cosmonauts in August 1976 identified two newer and larger ships, introduced in the early seventies, the *Kosmonavt Yuri Gargarin* and the *Akademik Sergey Korolev,* as operating in the Atlantic Ocean with the *Bezhitsa* and *Nevel* and maintaining reliable communications throughout the mission.[96]

Four new vessels, former freighters of the *Vytegrales* class rebuilt as space associated research ships in Leningrad during 1977-78 were added to the fleet to replace the aging *Dolinsk, Bezhitsa, Ristna,* and *Aksay.* The first to appear was the *Kosmonavt Vladislav Volkov,* followed the the *Kosmonavt Pavel Belayev,* the *Kosmonavt Georgi Dobrovolskiy* and the *Kosmonavt Viktor Patsayev.* On the eve of the recovery of the Soyuz 30 crew, the Moscow Home Service reported that the *Akademik Sergey Korolev, Kosmonavt Vladimir Komarov, Kosmonavt Pavel Belayev, Kegostrov, Nevel* and *Borovichi* had gone to predetermined areas to ensure communications between Soyuz 30 and flight control throughout the flight.[97] On the previous day Polish radio had reported that, on the night of July 2-3, three of the five ships had set off for their stations; the *Kosmonavt Vladimir Komarov* from Gibraltar for the Libyan coast, the *Borovichi* to latitude 15 degrees N off Brazil, and the *Kosmonavt Pavel Belayev* from Dakar out to sea.[98] Speaking in a recorded interview for radio, at the close of 1978, veteran cosmonaut Gherman Titov referred only to the three larger ships and the four newer ones, noting that the *Kosmonavt Viktor Patsayev* was soon expected to join the space service.[99]

A book giving a detailed description of the ships of the U.S.S.R. Academy of Sciences was published in 1980.[100] A Tass announcement describing the book claimed that the flotilla had more than 10 vessels operating in various parts of the world ocean. The need for them was explained by the fact that space vehicles are within direct visibility from Soviet territory only for about 9 hours out of 24.[101] Details on the principal ships follow.

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[95] Moscow Radio, 2200 GMT, Nov. 26, 1967.

[96] Moscow Home Service, 2050 GMT, Aug. 24, 1976.

[97] Moscow Home Service, 0800 GMT, July 4, 1978.

[98] PAP in English, 2124 GMT, July 3, 1978.

[99] Moscow Home Service, 0930 GMT, Nov. 5, 1978.

[100] Bezborodov, V., and A. Zhakov. Suda kosmicheskoy sluzhby. Sudostroyeniye. Leningrad, 1980.

[101] Tass in English, 1015 GMT, Nov. 20, 1980.

KOSMONAVT VLADIMIR KOMAROV

This was the first of the greatly improved Soviet tracking ships. It was launched in 1966 at Kherson as the *Genichesk* and operated as a Poltava class dry cargo ship in the Black Sea for about 6 months. It was converted to its present role at Leningrad in 1967. Prominent features are the unusual hull sponsons and the massive plastic radomes enclosing antenna arrays. It was first spotted by the West on a voyage through the English Channel while outbound from Leningrad to Havana, Cuba, which harbor it often frequented.

Tass in June 1970 said the ship has 1,000 or more berths, that it was built in 1967 at Leningrad, and has special computers and laboratories on board.[102] Pravda Ukrainy of June 23, 1970, said that it operated during the Soyuz 9 flight with a total complement of 240 men, including 125 scientists.[103]

The Russians have also said that communications between some spacecraft and Moscow can be maintained on a realtime basis even when not in direct view of the Soviet Union by having the *Kosmonavt Vladimir Komarov* serve as a relay point on Earth, with a further relay from the ship via one of the Molniya 1 satellites which shares mutual visibility between the ship and the Soviet Union. This type of relay was first mentioned in connection with the Soyuz 6-7-8 flights of October 1969.[104] A sketch of the vessel appears in figure 24.

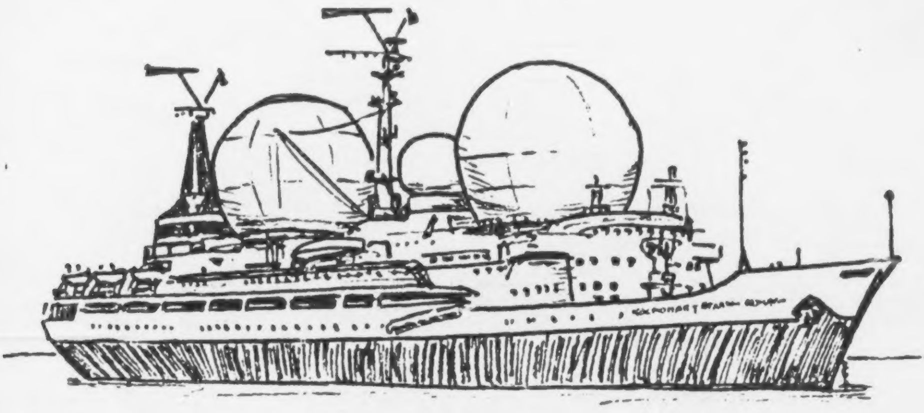

FIGURE 24. The civilian comprehensive space support ship *Kosmonavt Vladimir Komarov.*

AKADEMIK SERGEY KOROLEV

On December 26, 1970, the Soviet Union announced the addition to the fleet of the Soviet Academy of Sciences the space satellite control ship *Akademik Sergey Korolev.* Built at the Chernomorsky Shipyard, Nikolayev, it was described as the largest scientific research ship in the world, 182 meters long and displacing 21,250 metric tons. It was not further described, but was to set out on its maiden voyage early in 1971.[105] Details finally were forthcoming in September 1971. It was described as a diesel-engined ship with single propeller, a speed of 17.5 knots, and carrying a crew of 300. It had a radome just aft of the bridge, and two fairly large parabolic dish antennas, one amidships, and the other near the stern. The ship was described as having 28 suites of office, bedroom and bath for senior command staff, 34 single and 124 double cabins for crew and scientists. There was a gymnasium, two swimming pools (one enclosed), a library, reading room, and other cultural amenities. The ship had over 80 laboratories and dual air conditioning systems. The ship was active in the flights of Soyuz 10 and 11 serving as a link with Moscow via a Molniya satellite. It was built at Nikolayev on the Black Sea. With a range of 22,500 nautical miles, it was capable of 120 days of independent navigation without replenishment.[106]

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[102] Tass, 1964 GMT, June 5, 1970.
[103] Pravda Ukrainy, Kiev, June 23, 1970, p. 4.
[104] Izvestiya, Moscow, Oct. 19, 1969, p. 2.

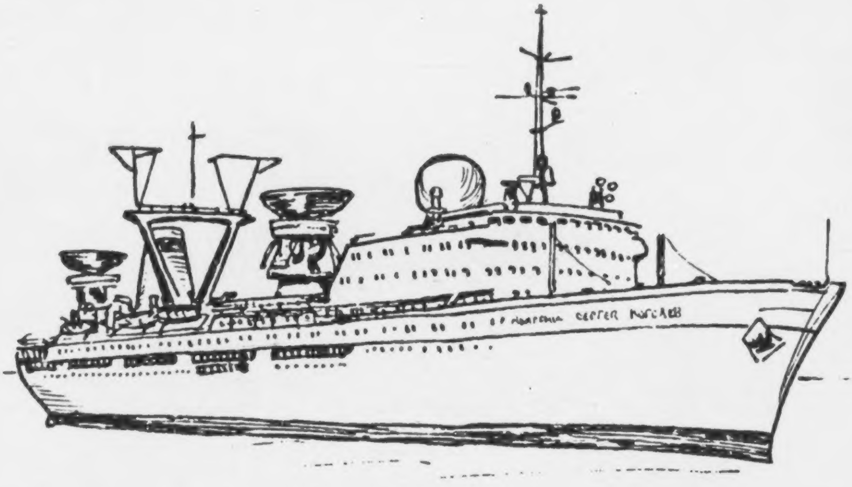

FIGURE 25. The even larger civilian space support ship *Akademik Sergey Korolev*.

KOSMONAVT YURIY GAGARIN

This vessel is the largest, most ambitious of the Soviet tracking ships. It was built at Leningrad by the Baltic S.B. and Engineering Works to a design based on the Sofia class supertanker in 1970 and made its first voyage in 1971. The first account spoke of its having over 120 laboratories. Its scientific instrumentation came direct from scientific institutes rather than from industrial enterprises, and units were designed for easy installation and replacement so that the ship could keep up to date as technology advanced. It was designed to operate away from home base for as long as 6 months at a time. It had a 19,000 horsepower turbine powerplant. The library had 10,000 books. Its theater seated 300 people. There were nine elevators, three swimming pools, and a sports hall big enough for a football match. There was also an automatic telephone exchange.[107]

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[105] Tass, 1817 GMT, Dec. 26, 1970.

[106] Kamenetskiy, Yu, T. B. M. Balabayev, and O. M. Zlatopo'skaya. *Akademik Sergey Korolev*—A New Scientific Research Ship. Sudostroyeniye, Leningrad, Nov. 9, 1971, pp. 3–4.

The ship was described as having over 100 antennas, and via Molniya satellites could reach almost any telephone in the Soviet Union around the clock. It was capable of receiving high data rates from satellites and amplifying weak signals at planetary distances. There were over 1,240 compartments in the ship.

The *Kosmonavt Yuriy Gagarin* has a displacement of 45,000 tons, a speed of 18 knots, has a length of 231 meters, and a width of 31 meters.[108]

Late in December 1971, a photograph appeared showing this ship anchored in Odessa, getting ready for its first operations. The first big dish antenna just behind the bridge was like a regular Orbita antenna for communication with Molniya. One of similar size was apparently intended to make trajectory and orbital data measurements. The two largest dishes further back were intended for deep space work. In the same photograph were the 17,500 ton *Kosmonavt Vladimir Komarov* and the almost 21,500 ton *Akademik Sergey Koroley*. An accompanying article noted the new ship had 11 decks, and spoke of its many marvels, including a precision navigation system; which permitted the antenna to correct for movements of the ship, movements of star fields, and also correct for angles of list and yaw in relation to the ship's course, and even for distortions in the ship's hull caused by heavy seas. This ship is also air conditioned throughout. Slightly different statistics credited it with 8 elevators and 260 seats in its theater.[109]

Still another account accounted 130 antennas in addition to the four main dishes. The ship's horsepower was listed as 19,500. It also has roll dampers and two maneuvering rudders in the bow and a third in the stern.[110]

The major antennas were listed as ranging from 12 meters to 25 meters in diameter.[111] A sketch of the vessel appears as figure 25.

The Bezborodov and Zhakov book quotes different numbers for the antennae and laboratories from those in the accounts mentioned above; 75 computer controlled antennae and 86 laboratories. Doubtless the explanation lies in the specification of computer control for the antennae and differences of opinion as to the designation of some of the accommodation as laboratories. Its automatic systems are said to make it possible to pick up signals from space with high precision even during Force 7 storms and communications are possible simultaneously with two or more satellites. With all four dish antennae facing forward the speed is reduced by two knots.

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[107] Leningradskaya Pravda, Leningrad, July 17, 1971, p. 1.
[108] Izvestiya, Moscow, July 18, 1971, p. 3
[109] Izvestiya, Moscow, Dec. 15, 1971, p. 4.
[110] Trud, Moscow, Dec. 14, 1971, p. 2; Krasnaya Zvezda, Moscow, Dec. 15, 1971, p. 4.
[111] Leningradskaya Pravda, Leningrad, Mar. 15, 1975, p. 4.

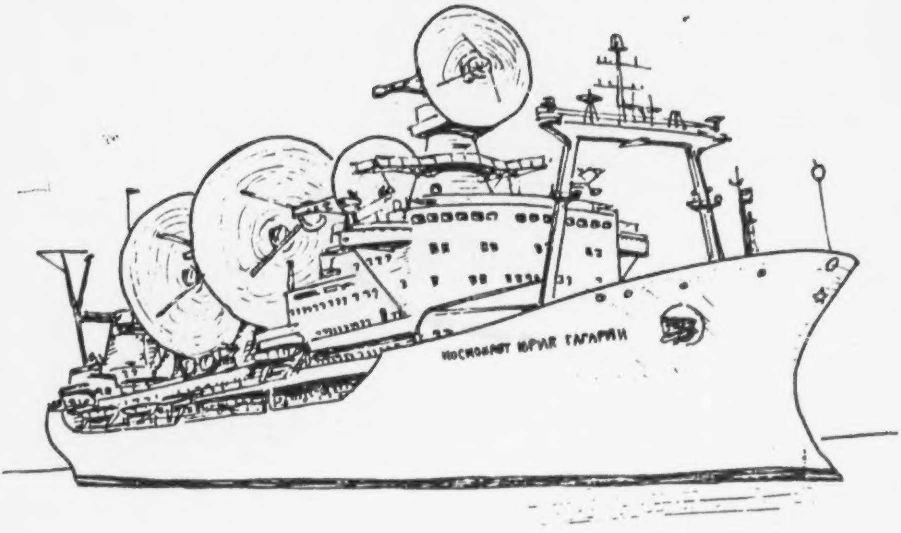

FIGURE 26. The largest of the civilian space support ships, the *Kosmonavt Yuriy Gagarin.*

KOSMONAVT VLADISLAV VOLKOV, KOSMONAVT PAVEL BELAYEV, KOSMONAVT GEORGI DOBROVOLSKIY, AND KOSMONAVT VIKTOR PATSAYEV

The four latest vessels to be added to the flotilla of space associated ships are all named after cosmonauts who have died. Pavel Belayev died as a result of complications following surgery. The other three were the ill-fated crew of Soyuz 11. Although similar in dimensions to the *Borovichi, Kegostrov, Morzhovets* and *Nevel,* which had been converted from timber carriers by the addition of tracking, direction finding and directional antennae, and the building of additional laboratories above the forward holds in 1967, these ships have more sophisticated antennae, including a multidish antenna amidships, reflecting the developments in space technology over the intervening years. The four-dish antenna amidships has four electrical feeds for the dishes, indicating the use of the monopulse autotrack principle for following transmitters across the sky. The feeds are log-periodic antennae providing wide-band coverage from the VHF to UHF ranges up to microwave frequencies. The *Kosmonavt Pavel Belayev* was said to be equipped with a new device which, unlike its predecessors, keeps its main antenna constantly fixed on its orbiting target even in the roughest seas. The prime function was said to be to receive signals from Soyuz spacecraft, while they are out of range of tracking stations on Soviet territory, and to transmit commands to them, acting as a relay between the crew in space and flight controllers on the ground.[112]

One of the first illustrations of this class of ship to appear was of the *Kosmonavt Vladislav Volkov* on the 6 Kopek value stamp in a set of six depicting research vessels issued in 1980. Another sketch is reproduced as figure 27.

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[112] Spaceflight, vol. 20, London, 1978, p. 344.

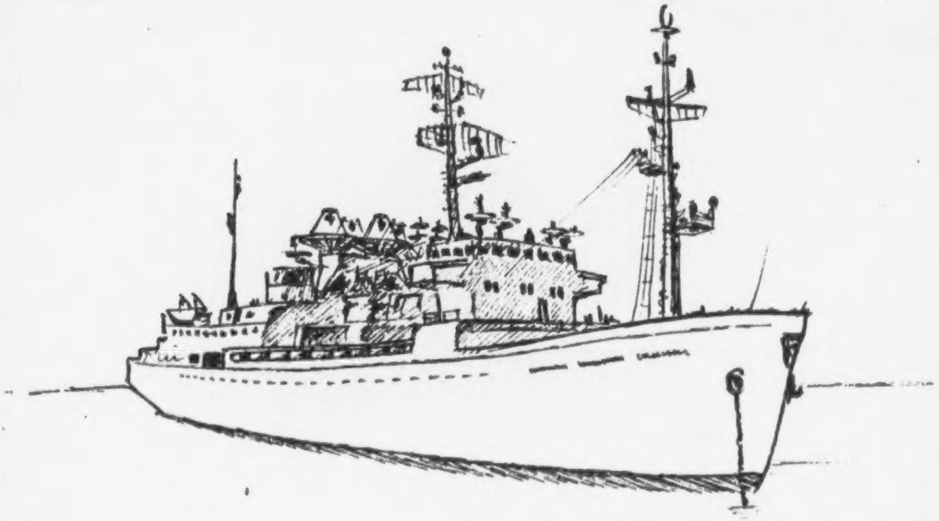

FIGURE 27. The newer civilian support ship, *Kosmonavt Vladislav Volkov.* The other three support ships in the series are similar in appearance.

The new tracking ships were a great advance over such vessels as the *Ilichevsk* and *Krasnodar,* used for space support in 1957 and long since disappeared.

Table 21, which follows, summarizes what is known from public sources about all the Soviet tracking ships.

TABLE 21.—CHARACTERISTICS OF KNOWN SOVIET SPACE AND MISSILE MONITORING AND CONTROL SHIPS

Name	Category	Displacement	Gross tonnage	Speed (knots)	Length (meters)	Width (meters)	Class and builder
Akademik Sergey Korolov	Civil	21,465	17,114	17.5	182	25	Nikolayev, U.S.S.R.
Aksay [1]	do	4,500?	3,359	13.5	105	15	Tanker, Rauma, Finland
Apsheron	Military	9,000	4,896	14.5	122	17	Vostok timber carrier, Leningrad, U.S.S.R.
Baskunchak	do	9,000	4,896	14.5	122	17	Do.
Bezhitsa [1]	Civil	17,000?	11,083	16.0	156	21	Poltava cargo ship, Kherson, U.S.S.R.
Borovichi	do	9,000	5,276	15.0	122	17	Svirles, Leningrad, U.S.S.R.
Chazma	Military	14,065	10,500?	18.0	140	18	Dzanskoy cargo ship.
Chukhotka	do	5,000	3,800	15.0	108	13	Bulk ore carrier, Gdansk, Poland.
Chumikan	do	14,065	10,500?	18.0	140	18	Dzanskoy cargo ship.
Dauriya	do	9,000	4,896	14.5	122	17	Vostok timber carrier, Leningrad, U.S.S.R.
Dikson	do	9,000	4,896	14.5	122	17	Do.
Dolinsk [1]	Civil	9,500?	5,419	14.5	139	18	Arkhangelsk, Abo, Finland.
Donbass	Military	9,000	4,896	14.5	122	17	Vostok timber carrier, Leningrad, U.S.S.R.
Ilichevsk [1]	Civil	8,500?	4,459	11.0	117	16	Voroshilov, Haverton Hill, England.
Kegostrov	do	9,000	5,277	15.0	122	17	Taimyr, Leningrad, U.S.S.R.
Kosmonavt Georgiy Dobrovolskiy	do	9,000	4,896	14.5	122	16	Vyregrales timber carrier, Leningrad, U.S.S.R.
Kosmonavt Pavel Belyayev	do	9,000	4,896	14.5	122	16	Do.
Kosmonavt Viktor Patsayev	do	9,000	4,896	14.5	122	16	Do.
Kosmonavt Vladimir Komarov	do	17,500	13,935	17.5	156	23	Geuichesk, Nikolayev, U.S.S.R.
Kosmonavt Vladislav Volkov	do	9,000	4,896	14.5	122	16	Vyregrales timber carrier, Leningrad, U.S.S.R.
Kosmonavt Yuriy Gagarin	do	45,000	32,291	17.0	236	31	Sofia oil tanker, Leningrad, U.S.S.R
Krasnodar [1]	do	10,000?	6,001	10.0	121	16	Empire Dart, Malmo, Sweden.
Morzhovets	do	9,000	5,277	15.0	122	17	Vostok timber carrier, Leningrad, U.S.S.R.
Nevel	do	9,000	5,277	15.0	122	17	Do.
Ristna [1]	do	5,000?	3,736	14.0	106	15	Neptun timber carrier, Rostok, G.D.R.
Sakhalin	Military	5,000	3,767	15.0	108	13	Bulk ore carrier, Gdansk, Poland.
Sevan	do	9,000	4,896	14.5	122	17	Vostok timber carrier, Lenimgrad, U.S.S.R.
Sibir	do	5,000	3,767	15.0	108	13	Bulk ore carrier, Gdansk, Poland.
Sutchan	do	5,000	3,710	15.0	108	13	Do.
Taman	do	9,000	4,896	14.5	122	17	Vostok timber carrier, Leningrad, U.S.S.R.
Tamal	do	9,000	4,896	14.5	122	17	Do.

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[1] Withdrawn from service. Other vessels may also, by now, be obsolete.

See notes p. 133.

NOTES

1. Data in this table are not wholly reliable because of differences among the sources used, but they are generally indicative.

2. The list shows alphabetically both civilian (Soviet Academy of Sciences) and military (Soviet Navy or possibly Soviet Strategic Rocket Forces) ships.

3. Displacements are presumably the weight fully loaded, in metric tons, most commonly applied to naval vessels.

4. Gross tonnage is the permanently enclosed space in a ship, less certain technical exceptions, and is measured in units of 100 cubic feet, not units of weight; this measure is the figure used for registry purposes of merchant ships (or converted merchant ships).

5. The estimates of speed, length, and width; (in knots, meters, and meters, respectively) differ among sources. One reason, even if data are available, is that speed made be that under full power, or used in normal cruising, or actual practice after a ship and its powerplant have aged. Dimensions may be overall, or between perpendiculars, or at the waterline.

6. Where known, the type of ship hull, or former name, or and the city of construction are indicated.

SOURCES.—Jane's All the World's Warships; Talbott-Booth Warship Identification, 1971; Jane's Fighting Ships, 1980–81; Lloyd's Register of Shipping, American Bureau Register; (anonymous) Soviet Merchant Ships, 1945–68, Kenneth Mason, 1969; Weyer's Warships of the World, by Gerhard Albrecht, U.S. Naval Institute, 1969; Tass reports.

OTHER TRACKING SHIPS

It will be noted from table 21 that four military tracking ships are relatively small. The *Sibir, Sutchan,* and *Sakhalin* entered service first, the *Chukhotka, Chazma,* and *Chumikan* followed with the latter two being larger and faster. The *Chukhotka* and *Chumikan* are shown in figure 28. It probably was not coincidence that during the recovery of the aborted Apollo 13 flight the *Chumikan* was in this remote part of the South Pacific, not near known Soviet test areas, when it offered assistance to the Americans. Undoubtedly its reason for being there was the collection of intelligence by studying the Apollo reentry ablation phase.

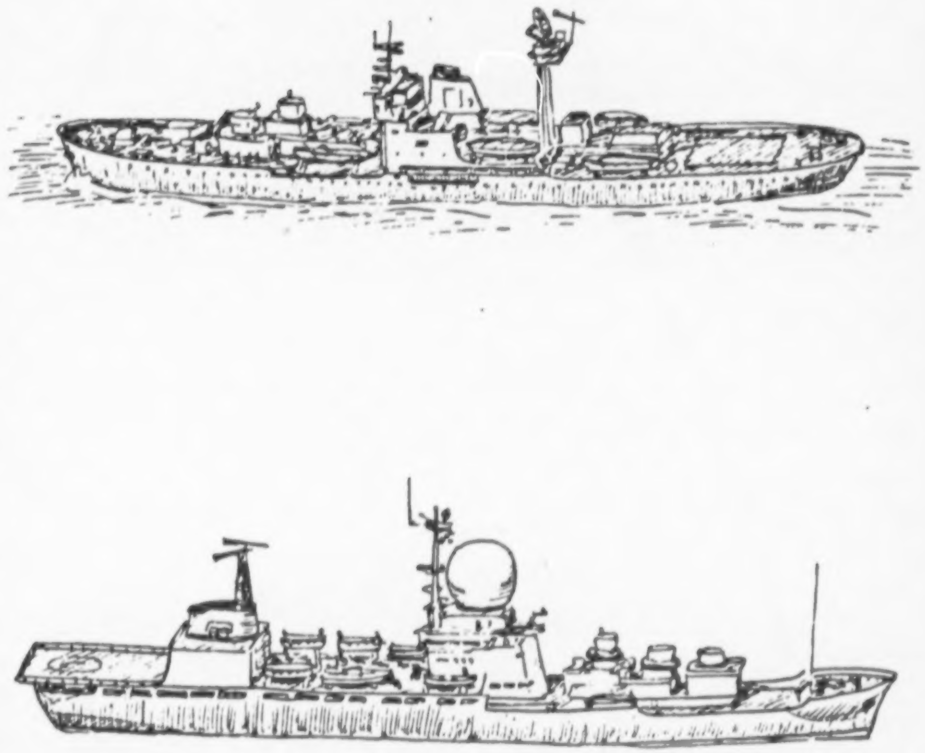

FIGURE 28. Military missile tracking ships: (a) The *Chukhotka*, very similar to the *Sutchan*, *Sibir*, and *Sakhalin*, and (b) the *Chumikan*, very similar to the *Chazma*.

Other tracking ships which have broken into the news, include the *Morzhovets* which was put under temporary arrest in a Brazilian port for violating territorial waters. During the Soyuz 9 mission, Trud reported that the *Morzhovets*, *Kegostrov*, and *Bezhitsa* were in the South Atlantic.[113] Sketches of some of these other vessels appear in figure 29.

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[113] Trud, Moscow, June 6, 1970, p. 4.

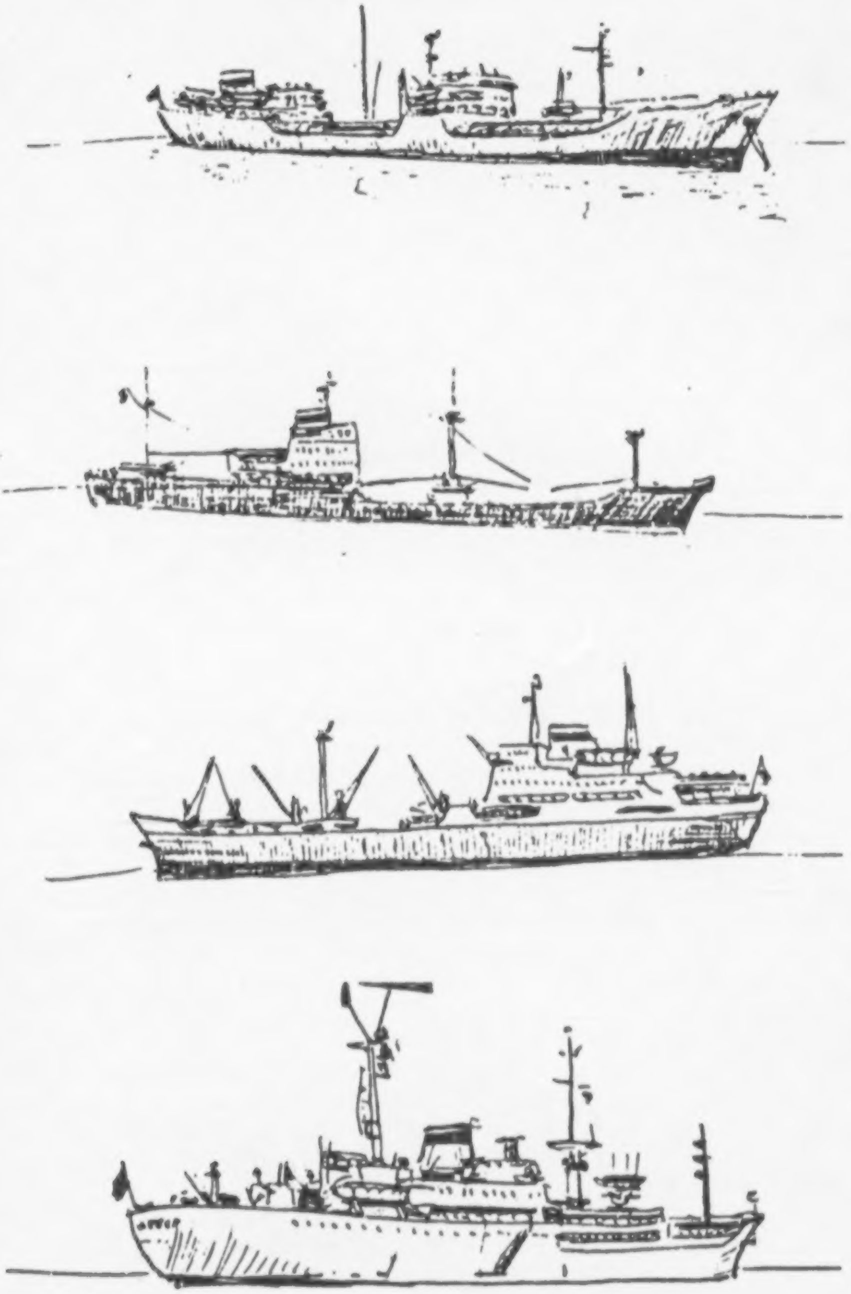

FIGURE 29. Civilian support ships: (a) *Aksay,* (b) *Ristna,* (c) *Bezhitsa,* (d) *Nevel,* very similar to the *Morzhovets, Borovichi,* and *Kegostrov.*

During the Zond circumlunar flights, the Russians have described how they deliberately plan for these to approach Earth over the polar regions, sometimes dipping into the atmosphere and then skipping out again before making a second reentry and landing. In one case, Zond 5 entered over Antarctica, but instead of developing aerodynamic lift to skip out of the atmosphere and home to the U.S.S.R., it made a ballistic reentry and landed in the ocean. The Russians had named five tracking ships as being in that ocean, and it was the *Borovichi* that made the pickup, but the capsule was transferred to a Soviet meteorological service ship, the *Vasiliy Golovnin* for carriage to Bombay, from where it was air-lifted home. Zond 8 also landed in the Indian Ocean, after a northern approach, but the ship making the pickup was not named.

Closely related to the Soviet Academy of Sciences ships like the *Morzhovets* and its three sisters are eight ships with naval crews that are not known to have supported the space program but apparently work on missile programs.

GENERAL LOCATIONS OF SOVIET TRACKING SHIPS

The foregoing paragraphs have referenced several of the places where Soviet tracking ships can be found during missions, but a comprehensive summary of these locations was prepared by James E. Oberg of the United States.[114] Captain Oberg mapped in relation to spacecraft ground traces the favorite places for the tracking ships. For example, he showed that during most of the Soyuz flights, one of the high capacity civilian ships anchors off Sable Island, Nova Scotia (about 44.5 N, 59.5 W) where four successive orbits pass within easy direct communication range. However, in some later phases of the Salyut 6 mission, this station appears to have been abandoned in favor of a new location in the western Mediterranean close to Gibraltar. Another location connected with the manned flights is in the Gulf of Guinea, West Africa, to monitor retrofire just before the reentry and landing near Karaganda in the U.S.S.R. In this same Gulf of Guinea area, deep space flights get their acceleration out of Earth orbit, so are often monitored there. When a deep space flight occurs, the ground trace reflects the combined effects of the acceleration to escape and the turning of the Earth itself. The ground trace goes east over Africa, Asia, and the Pacific, but as it climbs away from Earth, velocity is lost and the ground trace makes a U-turn over the South Atlantic and heads west over Central America. Hence, there are often tracking ships strung along this South Atlantic trace which otherwise would be unobservable with ease from Soviet territory. The Zond type of low G reentry from the Moon requires monitoring and potential pickup near Madagascar in the Indian Ocean when flights approach Earth over Antarctica. They also must be in the Indian Ocean between South Africa and Australia when such flights come in over the Arctic and land in the Indian Ocean. A large tracking ship either in a Cuban port such as Havana or Santiago, or in Trinidad gives added coverage to these deep space flights during early critical phases of the escape mission. During the ASTP mission, a large tracking ship was located off the coast of Honduras (at approximately 16 N, 87.5 W) to supplement the Sable Island position. A picture of the Soviet mission control center showed a ship location of the upper Delaware-area location during the Soyuz 35 docking.[115]

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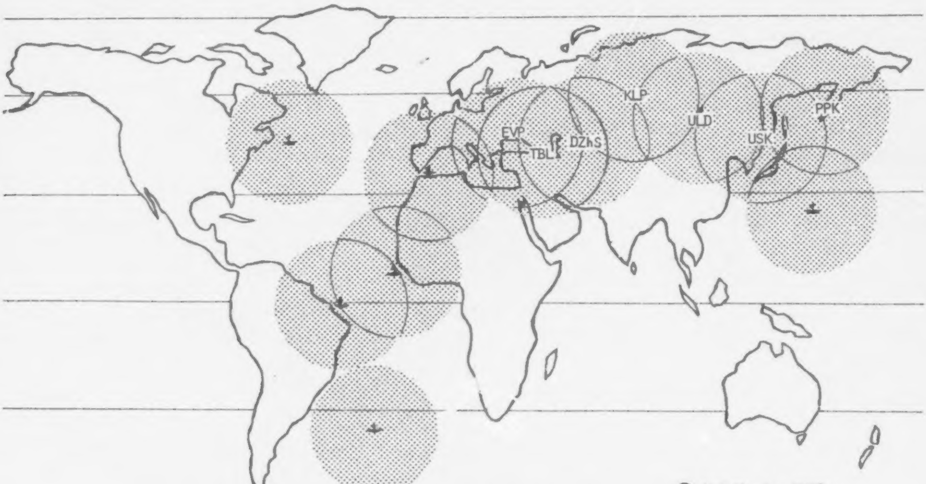
[114] Oberg, James. Soviet Tracking From the Sea. London, Flight International, Nov. 15, 1973, pp. 828–829.

The radio horizons of the various tracking stations within the Soviet Union and of the ships in their deployed positions are shown as ovals on the large world map display in the Kaliningrad control center. Pictures released at the time of manned missions to Salyut 6 appear from time to time in the technical press. One of these shows a previously unannounced ship location in the Pacific Ocean east of the Philippines.[116] This location is also shown together with another to the north of New Zealand on the 32 k value of the set of three stamps designed by G. Komlev to commemorate the Intercosmos joint flight of the Soviet and Polish cosmonauts, Petr Klimuk and Miroslav Hermaszewski, in June 1978. Also depicted on the same stamp is the Kosmonavt Vladimir Komarov.[117] Figure 30 is a map showing the location of the ground stations and tracking ships during the flight of Soyuz 39.



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Soviet ground stations at Yevpatoria (EVP 45.2°N 33.4°E), Tbilisi (TBL 41.7°N 45.0°E), Dzhusaly (DZhS 45.5°N 64.0°E), Kolpashevo (KLP 58.3°N 82.9°E), Ulan Ude (ULD 51.8°N 107.6°E), Ussuriysk (USK 43.8°N 131.9°E), and Petropavlovsk (PPK 53.0°N 158.7°E) provide communications coverage over Asia, during a space mission. Ocean going tracking ships extend this coverage. For this mission, ships have been deployed off Nova Scotia, French Guiana, west Africa, the south Atlantic, Gibraltar, and the western Pacific.

FIGURE 30. Soviet ground stations and tracking ships.

DEEP SPACE TRACKING

Reference has already been made to sea-based tracking in support not only of Earth orbital missions, but deep space flights as well. In the case of the United States, NASA saw a need for 24-hour worldwide coverage to support its deep space operations. It first built 25.9-meter steerable dishes at Goldstone, Calif., and in Australia, South Africa, and Spain, and these were followed by 64-meter dishes for Goldstone, Australia, and Spain.

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[115] Aviation Week and Space Technology, No. 18, May 5, 1980, p. 76.

[116] Spaceflight, vol. 22, London, 1980, p. 53.

[117] Perry, G. E. The Mission 15 Kopek. Stamp Collecting, vol. 137, London, June 26, 1980, pp. 1315–1319.

The Soviet Union could profit from a similar worldwide capability, but has not achieved the same level of coverage. Its equivalent of Goldstone is at Yevpatoriya in the Crimea, once visited by Sir Bernard Lovell, former director of the Jodrell Bank Nuffield Radio Astronomy Laboratories in England. The design approach used by the Russians has been different from the American approach. They seem to have two principal sets of antennas, each consisting of a single steerable mount carrying eight medium sized dishes arranged in banks of four. By operating these mounts along a railroad track, they could serve as an interferometer system. On the other hand, pictures show the antennae with two different types of feed. In one they have a Cassegrain system with a wide feed horn which can be used for frequencies as low as the UHF range which includes those close to 920 MHz employed by Luna and Venera probes. The other has a prime-focus feed connected to the receiver room by a narrow wave guide suggesting the frequencies in the 3.8–6.0 GHz bands used by Venera probes. Although both types of feed have not been discerned simultaneously in photographs, it may be that they are used in such a manner for different frequency ranges to provide system redundancy on the ground to insure a reliable data link. One would think it logical that there be a second installation in the Soviet Far East to expand their coverage, but if there is such a major station, it has not been revealed.

Beyond that, they rely on such devices as the three largest of their tracking ships which may take turns serving in the Caribbean area to extend Soviet deep space coverage. The only other Soviet recourse is to rely upon automatic systems in their deep space craft, or if more nearly real time data and commands must be exchanged, to plan their missions to have crucial events take place when that part of the world containing the U.S.S.R. faces toward the distant spacecraft.

Radio observations of Soviet telemetry transmissions made by amateurs in the West indicate the use of widely different frequency bands and differing modulation methods. Despite this, a high degree of standardization has been achieved. A limited set of modulation methods is used and distinct groups of carrier frequencies are employed. The combinations of modulation and frequency are numerous by virtue of the sheer size of the program. This standardization is typical of other components in Soviet spacecraft and is reminiscent of the standardization subsystem designs imposed by centralized engineering organizations serving individual design bureaus of the Soviet aviation industry. A high degree of standardization helps keep system development costs down but tends to produce some sluggishness in the overall program by the centralized introduction of new technology and innovations. However, standardization commits lengthy production runs helping to offset the slow innovation rates inherent in too stringently imposed standardization.

SPACE OPERATIONS AND DATA PROCESSING CENTERS

Early Soviet pictures of space operations centers looked very simple by U.S. standards, but gradually over time, the pictures have shown advances in the kind of equipment the Russians have available. The program was about 10 years old before detailed descriptions of control centers began to appear, and it was only with the Apollo-Soyuz Test Project that visits by Americans were permitted to one center.

Colonel General Tolubko described for Tass in November 1967 the role of the military in the launch of Venera 4, which can probably be assumed to be typical of so-called scientific flights. Members of the Soviet Strategic Rocket Force conducted the launch, and 10 minutes after lift-off, control passed from the military to the command measuring complex of stations all over the U.S.S.R. and on ships in several oceans.[118] That same month, Lieutenant General Leontyev stated that the Strategic Rocket Forces had been responsible for all launches of Sputniks, Lunas, Veneras, Molniyas, and the manned flights.[119]

In May 1968, Red Star described the computing coordinating center (KVTS) operated by the Soviet Academy of Sciences. This center collects data from stations all over the world where it is then processed, analyzed, evaluated, and compared. Red Star described the center as having a huge operations hall, with a large map of the world at one end on which the computed trajectories of the current spacecraft were displayed. Illuminated panels either side of the main map carry the principal steps of the launch countdown, and a status board of all other active Soviet payloads. Other walls are covered with more detailed diagrams, tables, graphs, and maps needed for the operation. The account went on to describe the receipt and use of many channels of telemetry.[120]

Pravda carried a further description in April 1969. This was in connection with the Venera flights. A side room was used for this purpose rather than the main hall. There were special telephones and apparatus for communicating with all computer coordinating centers and telemetry collection points throughout the U.S.S.R. Data on the flight position of the two Venera spacecraft then in flight were being plotted on a cylindrical recorder by tracing pens. In the telemetry section near by, the reporter saw more tracing pens plotting data from the spacecraft on paper bands. At the opposite end of the establishment were the big computers with the output unit passing out endless columns of numbers. In the main hall, primary data on the flight were being displayed on several large screens. The pictures were being drawn in full color diagrams by connection with a computer which was generating these displays directly from the telemetry.[121] This general description is highly reminiscent of the most advanced U.S. display systems.

More descriptions were released in June 1970. The reporter from Izvestiya reported that on the approach drive to the center he saw three large steerable antenna dishes which were receiving data. On this occasion it was Soyuz 9, and as soon as the ship came over the horizon, the large display screens showed live television from the cabin of the manned craft. He reported the tape was almost half a meter wide, as it poured out of a computer with many blinking lights.[122]

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[118] Tass, 0738 GMT, Nov. 16, 1967.
[119] Trud, Moscow, Nov. 19, 1967, p. 1A.
[120] Red Star, Moscow, May 16, 1968, p. 4.
[121] Pravda, Moscow, Apr. 12, 1969, p. 6.

A similar article in Krasnaya Zvezda discussed the problems of command and control during flights, recommending a combination of commands sent to the spacecraft by radio from Earth, and others program-timed on board the spacecraft itself. The report mentioned that the deep space flights launched from Earth orbit are observed by radio and sent command signals from ships placed in the Atlantic and Mediterranean, which is consistent with our knowledge that the probe or escape rocket is generally fired somewhere over or near Africa. Other flights are supported by aircraft, particularly during the recovery phase, supplementing the ships used for search, rescue, and evacuation of spacecraft which have landed in ocean areas. Information from all these sources feeds into the ground complex. The total combination of all support aids involves systems for orbital path measurements, reception and registry of telemetry, controlling onboard instrumentation, communications, and a standard time service. Communications may be relayed through Molniya satellites, and reliance is placed on the Meteor satellites for supporting weather data.[123]

Communications in near-Earth space require a greater number of antennas, but those for flights to lunar and planetary distances need special, large antenna systems, special molecular and parametric amplifers, and special narrow band filters to sort out weak signals amidst space "noise." At least two but not more than four deep space stations if sufficiently spread out, are all that are needed for planetary flights.[124]

Still another account in Pravda described the antennas as 25 meters in diameter at the main space flight control center. The main receiving antenna is close to the buildings of the center. The transmitting antenna to the spacecraft is about 10 kilometers away. Because several different frequencies are used, and these pass through the receiving antenna, special devices sort them out to deliver the separate components of television, telemetry, and telephonic information. These are all recorded on magnetic tape, while the information on orbital information especially is fed immediately to the computers. When commands are sent to the spacecraft, these are in coded form which has been put into the computers, so that only pressing a button on a panel is required. When these signals are played back to Earth correctly from the spacecraft, only then does the "execute" command go out to the spaceship.[125]

It was interesting that through all these years of partial disclosure, there was never a clue as to the location of the space control centers. Certainly the launch itself is controlled by military men at the individual launch sites. It was this immediate block house with its periscopes that was declared off limits when American astronauts, technicians, and other higher officials visited Tyuratam in connection with the Apollo-Soyuz mission.

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[122] Izvestiya, Moscow, June 4, 1970, pp. 1, 4.
[123] Dmitriyev, G. Eyes and Ears of the Earth. Moscow, Krasnaya Zvezda, June 12, 1970, p. 2.
[124] Idem.
[125] Smirnov, V. Information From Orbit. Moscow, Pravda, June 9, 1970.

When the Apollo-Soyuz mission was approaching, the Russians opened some more information by making known they were building an entirely new space control center for this mission in the general vicinity of Moscow. It was revealed that the Soyuz 12 flight was the first one controlled from this new center northeast of Moscow.[126] At first the site was believed to be at Kalinin, 150 kilometers northwest of Moscow. But the site was finally located accurately when the U.S. press representatives were allowed to visit it in mid-May 1975. It was in Kaliningrad, 10 kilometers northeast of Moscow and 10 kilometers northwest of the Yuriy Gagarin Cosmonaut Training Center at Zvezdny Gorodok.[127] It had been building since 1970. The main operations room has 5 banks of consoles, 24 in total with a large screen map of the world in front center, with the orbital path and all tracking stations shown on the map with additional data listed on side panels. A drawing, based on photographs of the interior of the main operations room, is shown in figure 31.

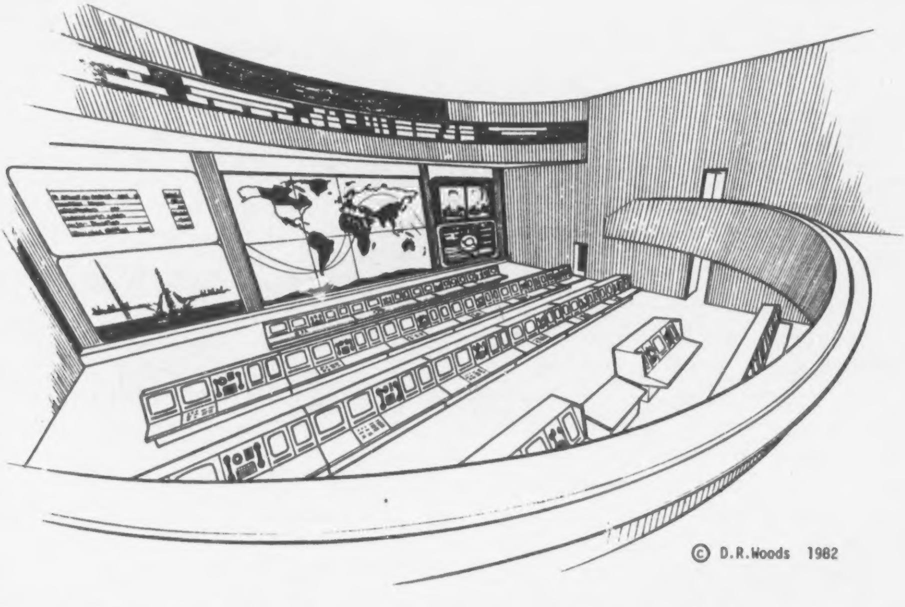

FIGURE 31. Interior of main operations room at the mission control center at Kaliningrad, northwest of Moscow. (Drawing by D. R. Woods based on a photograph from a Soviet publication.)

It is evident from these disclosures that there must be a different and possibly more versatile center already in use elsewhere. The Russians were evasive on this point, but during the Apollo-Soyuz mission mentioned almost casually that the Salyut mission was being controlled from a center at Yevpatoriya, the same site in the Crimea where the deep space tracking station is located. Still more information became available when the official histories of ASTP appeared in 1978 and 1979. The Russian description, by Lev Lebedev, a senior researcher at the Institute of Space Exploration of the

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[126] Aviation Week, New York, Nov. 5, 1973, p. 20.
[127] Soviet Aerospace, Washington, May 19, 1975, p. 18.

U.S.S.R. Academy of Sciences, does not refer to the second control center. It defines flight control and lists other responsibilities of the Mission Control Center including determination of orbital parameters and calculation of any maneuvers necessary for changing the orbit, rendezvous with another spacecraft, and reentry. The account continues with a description of the personnel, their roles, and the equipment. The cycle of operations is described in the following extract.

> When the spacecraft enters a ground station's zone of radio visibility the transmission of commands to the spacecraft in conformity with the flight program begins. The relevant on-board systems are switched on. The ground stations start to receive and to retransmit to Mission Control Center telemetric and trajectory information and also TV images from the spacecraft. The telemetric and trajectory information is automatically processed by the Mission Control Center computers and serves as the basis for further control decisions. Specialists analyse the incoming data and assess the condition and operation of each on-board system.
>
> In case of deviation from the normal modes of on-board systems operation they analyse the effect of the failure on each system and prepare proposals to eliminate the failures. The medical officer thoroughly analyses the biotelemetric data and assesses the physical condition of the crew. The cosmonaut communicator carries out voice exchanges with the crew. The specialist responsible for the ground station network monitors the operation of the stations, with which he maintains direct communication.
>
> The Shift Flight Director summarises all the incoming data and makes decisions with regard to the further flight program. If no deviations in the functioning of the on-board and ground systems are observed he gives permission to proceed with the nominal program. If program correction is required it is done by the specialist responsible for program planning. Corrective actions can be taken during both the current and subsequent events. In case of need the spacecraft model and cosmonaut complex simulator can be utilized for failure identification and corrective action verification.[128]

A black and white photograph of the interior of the Kaliningrad control center is to be found in the same book.[129]

An account of a visit by American ASTP specialists to the Kaliningrad control center by M. P. Frank, a flight director, is given in some detail in the source notes of the Ezell's The Partnership.[130] He gained the impression that the center was no more than 3 years old and, although impressed by its quality, he had the definite feeling that it did not have the performance capability of the American control center. He went on to give details of the computer facilities which consisted of three main frames, each containing 16 memory drums with a capacity of 32,000 48-bit words.

In addition to former cosmonaut, Aleksey Yeliseyev, the Soyuz flight director for ASTP, two other Soviet officials were named in the account of the October 18, 1973 visit: Dr. Abduyevskiy, the deputy director of the control center, and Dr. A. Melytsin, the technical director. The visitors were told that the facility had been used in the past for unmanned flights but that Soyuz 12, 3 weeks earlier, had been directed from there. They planned to direct future Soyuz missions, including ASTP, from there.

In an exchange between Senator William Proxmire and NASA Administrator, James C. Fletcher, shortly before the ASTP mission, it was disclosed that Prof. Konstantin Bushuyev, Project Director for the U.S.S.R., had assured his American counterpart, Dr. Glynn S. Lunney, that in the event of the Soyuz 18/Salyut 4 mission overlapping ASTP, the Soviets would use two separate ground control teams and control centers for the two missions. ASTP would be directed from the center at Kaliningrad, while Soyuz 18/Salyut 4 would be conducted by the center that had been used prior to Soyuz 12. Whether there are still other major control centers is not known. It is reminiscent of the fact the United States has control facilities at each of its major launch sites in Florida and California, and also has additional facilities in Houston, Tex.; Greenbelt, Md.; and Sunnyvale, Calif. at the very least. So for some purposes, the Russians may also have additional locations in use.

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[128] Lebedev, L., and A. Romanov, Rendezvous in Space: Soyuz-Apollo, Moscow, Progess Publishers, 1979, pp. 74–77.

[129] Id., pp. 72–73.

[130] Ezell, E. C., and Linda N. Ezell. The Partnership: A History of the Apollo-Soyuz Test Project, Washington, D.C., NASA, 1978, pp. 388–389 (NASA SP–4209, 1978).

SPACE RESEARCH CENTERS

Reliable information about Soviet space research centers is also limited. There are a few which have come to public attention. For example, the engine development work of the Leningrad Gas Dynamics Laboratory has been revealed through research publications of a theoretical nature, and early experimental engines as well as a few currently operational engines have been put on display and described as developed there. There is even a museum in Leningrad where it is possible to see these products.

The large body of published literature in various fields of space sciences reveals researchers in many scientific institutes pursue studies of geophysics, the upper atmosphere, radiation, space medicine, the planets, the Sun, and so forth. But it is not possible from these papers to build a definitive list of titles and locations of space laboratories and centers. It can be assumed that some are in the new science cities which have been created in several parts of the Soviet Union.

A fairly detailed description of one major institute was provided during 1971. The Moscow Space Research Institute of the Soviet Academy of Sciences consists of administrative buildings, parking lots, and laboratories in the central area, with experimental and storage areas at the back. The administrative building has 3 stories, underground parking, a library, conference and reception rooms, and an auditorium seating 1,200 persons. The laboratories are in a 13-story building with 2-story annexes. There are special air-conditioning units in towers nearby. All told, there are 41,000 square meters of floor space, including 33,000 square meters in laboratories; and the building volume is 599,870 cubic meters, including 534,700 cubic meters in laboratories.[131]

It has been reported that a branch of the Space Research Institute is being established at Tarusa in Kaluga Oblast.[132] Foundations for a new building, to be constructed by Yugoslav specialists, had been laid. A new satellite communication center had already begun operation and there were plans to carry out extensive research during the 1980's into astrophysics and studies of the solar system.

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[131] Stroitelstvo i Arkhitektura, Moskvy, Moscow, Nov. 1, 1971, pp. 26–29.

[132] Moscow Home Service, 1630 GMT, May 23, 1981.

MANUFACTURING AND ASSEMBLY CENTERS FOR SPACECRAFT AND ROCKETS

Few details are available on Soviet factories equivalent to those of American industry in which specialized craft are built or where "serial" production is carried on. Occasional American visitors have been allowed to visit aircraft factories, and it is always possible that some space manufacturing is done in closed but adjacent buildings in some of these aviation centers. Occasional photographs have shown assembly lines for Vostok and for Soyuz spacecraft, and the numbers of such craft shown in the pictures strengthens the notion that the same basic shells are used for the large unmanned recoverable Kosmos flights used by the Soviet military to conduct observations of interest. Somewhere there must also be a production line for the smaller Kosmos, because many use the same basic shell, with modifications to fit the particular missions of the craft.

Except for the very largest launch vehicles, presumably almost all components are rail-transportable, especially as the Soviet railway lines have a generous clearance guage through tunnels and stations. We know both through Soviet movies and through the recent visits to Tyuratam that launch rockets and payloads are brought together in assembly buildings within a few kilometers of the launch pads, with the mating done horizontally, and then the combined rocket and payload pushed out to the pad atop flat cars and special transporters by diesel locomotives. At the pad, the transporter tilts the rocket up into a vertical position for final checkout and launch. This may not be true of the G-1-e class vehicles, but seems to apply even through the D-1-e class.

TEST AND TRAINING CENTERS FOR SPACE

Of necessity the Russians must have test stands for rocket development, and environmental chambers for rockets and payloads. These are not described as to location in the open literature.

Because of the numerous Soviet failures in planetary payloads, they have come to the American practice of having a duplicate payload in an environmental chamber undergoing as nearly as possible the same conditions as the actual spacecraft in flight, so that if problems develop, solutions can be tested with the laboratory "bird." This was first announced as the practice with the Venera 4 flight.[133] Something similar has been hinted at in connection with manned flights in 1974 and 1975.

The principal test and training center for Soviet cosmonauts is at Zvezdnyy Gorodok (Star City) east of Moscow in the suburbs. This has been visited by both the American astronauts and NASA technicians, and also by the Western press.

On July 21, 1980, Tass reported that the Gagarin cosmonaut training center at Star City was 20 years old, pinpointing its establishment at a time just after the first unmanned test of the Vostok spaceship.[134] Facilities at the center were said to include class-rooms, laboratories, scale models of spacecraft and orbital stations, a sports training complex, centrifuges, thermal chambers and other equipment to simulate conditions in space. Among the latter was a new pool, 23 meters in diameter and 12 meters deep, containing models of a Soyuz craft and a Salyut station. In this neutral buoyancy facility, cosmonauts, wearing spacesuits, practiced various operations in space, such as extravehicular activity to examine the exterior of their craft.

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[133] Tass, 0800 GMT, Oct. 19, 1967, quoting Komsomolskaya Pravda, Moscow.

[134] Tass in English, 2005 GMT, July 21, 1980.

The official ASTP histories do not add greatly to this description. The Lebedev and Romanov book has a color photograph of the simulation hall in the cosmonaut training center.[135] Accounts of visits by American delegations in October 1970 and October 1973, in the Ezell's book,[136] refer to a manned spaceflight museum with a reconstruction of Gagarin's office and the memorabilia collected by him on his subsequent world tours. NASA Deputy Administrator, George Low, on his second visit, saw more of Star City and was impressed by the amount of new construction taking place.[137] A new four-story training building was being erected especially for ASTP. In addition they were building a new hostel and dispensary for the U.S. team. Star City provides good living accommodations for the cosmonauts and their families, and associated scientists and technicians.

Apparently there are some facilities for training in the Tyuratam area, presumably in or near the new, burgeoning city of Leninsk. The American visitors found the accommodations provided at Leninsk to be equal or superior to those provided at the Kennedy Space Center. The cosmonauts when suited up for flights ride out to the pad in a well-equipped, air-conditioned bus, much in the manner that NASA astronauts are transported.

When the Soyuz 9 cosmonauts returned to Earth, they went to a special isolation center, which was highly reminiscent of the Houston quarantine facility, perhaps as a dry run for similar procedures once Soviet cosmonauts return from the Moon.[138]

The lunar material recovered by Luna 16 on the Moon was also taken to a special isolation laboratory at an unspecified point which employs the same general kind of procedures to preserve freedom from contamination, both in and out, as Houston has supplied for its Lunar Receiving Laboratory.[139]

All in all, one is struck with the close parallels between the United States and Soviet programs in terms of procedures and equipment, but also with the paucity of definitive Soviet information in the public domain on any of these matters aside from the few facilities which have been occasionally opened to visitors.

FUTURE OUTLOOK

INTRODUCTION

The preceding sections have discussed Soviet space vehicle and launch activities and programs for the years 1976 through 1980 inclusive in greatest detail, plus providing considerable historical material to summarize earlier flights and to complete time series in statistical tables. There have been some occasional references to trends and extrapolations which pointed toward the future. The purpose of this section is to deal more systematically with what the Soviet Union may do in the years ahead.

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[135] Ibid., pp. 46–47.
[136] Ibid., p. 110.
[137] Ibid., p. 2233.
[138] Tass, 1704 GMT, June 20, 1970.
[139] Tass, 1077 GMT, Sept. 26, 1970.

HOW PLANS CAN CHANGE

No one has found a reliable technique for reading the future of the Soviet space program, and this study will not be able to break new ground in this regard. What it will do is identify and comment upon existing trends, assemble quotations on what the Russians themselves have said about their future activity in space, and provide some possible scenarios for implementing some of the projections.

Recent history seems to provide little confidence for assertions that some political systems are inherently more likely to follow a steadier course than others. There are differences of appearance and detail in the decisionmaking process in Western-style democracies and in more centralized societies where decisions seem to come from the top down. These differences in certainty of plans are so contradictory and kaleidoscopic, that almost any model explaining the differences can be challenged.

In the United States, budget decisions are made each year for many programs and some people fear that the United States can "blow hot and cold" so quickly that orderly progress is difficult. But we also use "no-year" funding for some projects and we increasingly supply at least 5-year cost-outs on projects. Also, other programs are funded on a mandatory basis, so that the amount of the Federal budget which is truly controllable each year is so limited as to make freedom to be flexible not always easy. In our representative form of government, with checks and balances among the legislative, executive, and judicial branches, the pattern suggests that major decisions usually require a fairly broad base of public support, and wild swings may be tempered by the almost cumbersome process of bringing together all interests that make inputs.

In the Soviet Union, it is possible that decisions from the top down on the one hand can change very quickly without a popular referendum, but also some decisions can continue for many years without the annual budget contests between a President and a Congress faced in the United States. But presumably the political system of the Soviet Union as in other states must be responsive to some degree of a consensus if it is to survive for long.

In the United States, in spite of our slow processes where issues move through the bureaucracy and the Congress, and where many interest groups throughout our society make their inputs, we have had an example of a fairly sharp shift in attitudes. In the summer of 1969, Apollo 11 reached the surface of the Moon, a great euphoria swept the public, and many foreign nations also seemed not only to be impressed with the achievement, but to share in the success. The Vice President called for a manned expedition to Mars. But within a matter of months, it seemed as if the space program fell into some lower estate with much more attention focused on ecology, pollution, and social changes. It was popular to label the space program as a misguided and not very useful effort. Actually, space expenditures in real dollars had peaked in the middle 1960's and have been going downhill quite markedly since that time.

Although we can study Soviet decisionmaking from its outward manifestations, many of us have less of a feel for the subtleties of their processes. Over recent decades we have seen changes in Soviet political alignments. There was the Russo-German pact of 1939; then the U.S.S.R. was an ally of the Western democracies; post-war America became the prime "enemy" of the Soviet bloc; then, 1975, our men flew together in space. An agreement for further cooperation in the area of manned spaceflight between NASA and the U.S.S.R. Academy of Sciences was signed in May 1977. This provided for a possible joint spaceflight of an American Space Shuttle and a Soviet Salyut orbital station but, following several meetings in 1978 to discuss the feasibiliy and estimate the cost, the project was shelved on orders from the Carter administration. Soviet intervention in Afghanistan further exacerbated the situation and prospects for a revival of the project in the foreseeable future are not encouraging.

Probably careful analysis will show consistent threads of national interest prevail in both kinds of societies, but the current manifestations can seemingly change quite abruptly and even arbitrarily. The task here is to discern some of the underlying, persistent goals, but to recognize the sharp shifts of direction which may occur from year to year.

PAUCITY OF SOVIET INDICATORS

It is hard enough to predict trends in the U.S. space program when business cycles and popular enthusiasms of particular times shift the relative priority of work on space. Estimating Soviet behavior has added difficulties. They have never provided a table of space expenditures or budget commitments. Even if they did, there would be translational difficulties to understanding what they were doing when the costs of the factors of production in the two countries give entirely different ratios to the relative values of different inputs. In the absence of any economic measures, we have to fall back on counting the number of flights, estimating weight of hardware, and looking for clues to Soviet attitudes in speeches and articles.

To a considerable degree over the last 25 years, the two space programs, American and Soviet, have interacted politically with each other, regardless of disclaimers by leaders in the two countries. This interaction means that judgments of either program cannot be taken in isolation but must be tempered and modified by what each observes or assumes about the other nation. Hence, what the United States decides on the Space Shuttle, planetary flights, Earth resources satellites, and military applications could have significant repercussions in Soviet planning as well. That is not to say reactions are one for one, merely that size and pace of programs and sometimes the choices to avoid direct overlap and sometimes deliberately to race to be first or to excel will all be possibilities. The repercussion will be there even if we cannot predict its nature.

EFFECTS OF PERSONALITIES AND SPORADIC EVENTS

Analysis would be more manageable if all that had to be worried about was a study of long term national aspirations and economic conditions, together with the state of the art in technology. Human history is still so affected by personalities and by natural calamities or other sporadic events that our present state of knowledge does not permit us to predict precisely.

The appearance of a particular personality may be partly a response to the times, but the sudden ouster of Premier Khrushchev or the assassination of President Kennedy could make a difference in support for a program. Most observers feel the death of Chief Designer Sergey Korolev made a real difference, a setback to the Soviet program. Certainly deaths of cosmonauts or astronauts in accidents bring investigations, delays for redesign, and more boldness to critics of a program. The failure of the Soviet G–1–e launch vehicle to achieve a successful flight in 1969 or during the 11 years thereafter must have affected the Soviet timetable if not the objectives of some parts of their space program.

CAPABILITIES VERSUS INTENTIONS

With all these caveats and examples of uncertainty, perhaps the proper mood has been set for examining the future of the Soviet space program. There is an analytical distinction in forecasting work which is common to military affairs and equally appropriate here. This is to recognize the difference between capabilities and intentions. A careful study of past performance, manpower, economic strength, production facilities, and other ingredients will answer reasonably well what a nation might be able to do. But no nation has the resources to pursue all of these capabilities simultaneously, and the more difficult task is to divine intentions. The verb "divine" is selected deliberately, because there is no real science to knowing what the future choices will be. As events come closer, there are indicators that give clearer and clearer warning. But longer range forecasts are harder. Also, in high technology some projects can be undertaken with several subsystems not yet in hand, but if good resources of brain power, laboratory facilities, and computers are applied, the capability will appear and grow, assuming what is sought is within the limits of the laws of nature.

Presumably, if the Russians set their priorities high enough on a few projects, and apply their best talents to them, they should be capable of advancing as fast as any nation could hope to in these selected areas. Neither the Soviet Union nor the United States has the resources to pursue all avenues and all programs their engineers and scientists can propose in good faith. In a largely closed society in contrast with our own, it is sometimes hard to read intentions until a time almost too late to adjust one's own responses. The study of the Russian's own predictions of what they will do in space is interesting, sometimes helpful, and sometimes not very meaningful because no time scale is provided.

GENERAL TECHNICAL CAPACITY

OVERALL SUPPORT

Industrialization and gross national product

Judgments vary as to where the Soviet Union is in technology relative to the United States. Overall, as a less developed country it is not as advanced, and field by field, people close to that field are able to estimate "on a par or ahead," or "2 years behind," or "6 years behind," or "not in the running." An overall measure of comparison is the amount of Soviet gross national product, which is said to be about half as large in the aggregate as that of the United States. But the closer one comes to learning how such estimates are built, the more elusive the comparison becomes. Any two societies or even the same society in different decades have such changes and differences of product mixes that comparisons of GNP may be generally indicative but cannot be precise measures. Whenever United States-Soviet comparisons are made in ruble prices, the ratios are quite different from the comparison if made in dollar prices.

The industrial revolution began in Russia before World War I, but well after it was fairly advanced in Western Europe and the United States. Between World War I and World War II, the Russians paid a considerable price by collectivizing their farms and putting stress on heavy industry to the exclusion of many important aspects of balanced growth. Armaments have been a heavy drain, and the physical destruction of World War II was very great. Growth some years has been high compared with the United States because the base figure was so low, but the growth was not as great as that shown by postwar Germany and Japan, which also suffered heavy war damage. The phenomenon of slower growth rates now is almost worldwide. Today, while Soviet consumers may be better off than they have been in the past, the U.S.S.R. lags behind even some of the Soviet bloc countries of Eastern Europe, because of a continuing emphasis upon industrial growth and military hardware. The Soviet economy today is large enough and strong enough, despite shortages, that it can support what is now the world's largest space program, with no sign that this level of effort cannot be sustained indefinitely.

Key industries

By selective application of the most efficient parts of their economic and technical structure, the Russians have been able to match the performance of other leading countries in selected fields, when they have chosen to do so. The general view has been that they are behind in electronics, microminiaturization, computers and some kinds of chemistry. All such comparisons are relative and subject to change. It is easier to point to specific examples than it is to quantify any overall comparisons. For example, although their electronics may not be the very best, some of their radars are rated as quite good. We know they do not have as many computers as the United States, and probably are not as advanced in the computers they have, but the kind of estimates one receives are that they may be about one generation behind, perhaps 4 or 5 years, while it was not so long ago they were two generations behind the equivalent 7 to 9 years. While clerks in a store may use the abacus, computers in high priority uses are conducting support for space rendezvous and missile intercepts, or supporting the Gosplan. Hence, even if it was judged that in many technical fields they were 2 to 5 years behind the United States, that would hardly be a basis for writing off their capacity for further progress, or for finding ways around some specific limitations.

Education and manpower

The Soviet Union today has a larger student population in science and engineering than does the United States. While the two countries are more or less matched in numbers of working engineers and scientists, any extrapolation of trends based on the number being trained gives the Soviet Union a strong emerging lead. However, some studies suggest that much Soviet technical training is narrower, and in a time when many people end up having more than one career as national needs change, the American trained engineer may prove more adaptable collectively than the Soviet counterpart. At the top, the very best people in terms of performance, breadth of grasp, creativity, are about equal in both countries.

The Soviet Union is a nation with a large population, many technical institutes, a good base of trained manpower, and reasonably good access both to their own many scientific journals, and the shared world community of knowledge. If it chooses to pursue a large space program that is both vigorous and ambitious, it is in as good a fundamental position to achieve this as any nation.

SUPPORTING HARDWARE AND FACILITIES FOR SPACE

Launch sites

The Soviet Union demonstrates from time to time that its three launch sites, each of which is spread over many square kilometers of terrain and with multiple pads, are capable of conducting a considerable number of space launches in a few days. Their annual total launches are the highest in the world even though some pads and some vehicles are used only sporadically. Perhaps a contributing factor to high launch rates is the checkout for many vehicles done in horizontal assembly, followed by rail movement to the launch pad and a short time in vertical position on the pad before launch. This type of launch may be typical even of the D class launch vehicles, but less is known about the long-delayed and uncertain-performing G class vehicles which are so large that they may have to be assembled and tested on the pad. The introduction of a fourth launch site is unlikely in view of the fact that Kapustin Yar now launches only one or two satellites per year along with some Vertikal sounding rockets. It may eventually be phased out as is the case with Wallops Island, its American counterpart.

Tracking systems

The Soviet Union still lacks a deep space worldwide network equivalent to that used by NASA, but manages passably by timing major activities to occur within view of Yevpatoriya in the Crimea.

There may be another deep space capability in the Soviet Far East, but this has still not been confirmed. Additionally, their three largest tracking ships, and the four newer replacement ships, while falling short of the high capacity of Yevpatoriya, can give important global coverage, especially up to lunar distances.

Soviet ability to do automatic rendezvous and docking with large spacecraft, intercepts, and geosynchronous flights suggests their general Earth orbital capacity is at least adequate. On more than one occasion they have demonstrated the capability of managing and controlling several manned and unmanned spacecraft simultaneously. We also know that they have at least redundancy in control centers having these at Yevpatoriya and Kaliningrad as a minimum.

Manufacturing and testing of space hardware

We do not know in detail what their full capabilities are in this regard. It has been believed in the past that ground test facilities were limited and many vehicles and payloads were tested in all-up flights with a consequent higher loss rate than would otherwise likely apply. Virtually all major flights now are described as being matched on the ground by an analog in a test chamber on which commands can be tested, and fixes in emergencies tried before commitment to the flight itself. There is probably some basis for belief the Russians do not have as much computer capacity dedicated to checkout and testing as do their American counterparts.

Because the continuing Soviet flight program itself is so massive year after year—seven times that of the United States—there seems little challenge to the notion they can sustain the present high level of activity indefinitely. The introduction of the American Space Shuttle should now go some way to redressing the imbalance in manned spaceflight which has developed in the 5 years under review during which period the Soviets accumulated more than 36,000 man-hours while the American total remained stationary at around 22,000 man-hours. More significantly, the Soviet total progressed from less than half to more than double that of the United States. If the Soviet economy maintains its growth rate, Soviet capabilities will be enhanced as their computer capacity grows and as they apply more attention to cybernetics, to quality control, and to advanced industrial management and operation.

VEHICLE CAPABILITIES

Existing vehicles

The spectrum of existing vehicles is adequate to take care of a fairly comprehensive space program. Although the A class of vehicles, in use since 1957, may eventually be declared obsolete. Through upgrading of payload capabilities, some tasks previously handled by the A and C class vehicles are now being handled by the F class. Payloads handled by the low capacity B class vehicles now are totally handled by the more powerful and more versatile C class.

The D class launch vehicles are gradually becoming more reliable, even though not yet proven as man-rated in the launch phase. Its use, in 1981, to launch Kosmos 1267, described as a new type of supply craft for Salyut orbital stations, may point to an intention to man-rate it in the near future. Capsules reported to have been returned to Earth from Kosmos 1267 and its predecessor, Kosmos 929, may well have been prototypes for manned reentry capsules as may the dual Kosmos payloads orbited by D–1 and recovered after only one orbit.

The use of F class launch vehicles for military missions has increased and it now finds use for launching scientific and applications payloads from Plesetsk. It may eventually replace the A class for all but a few specialized missions.

The G class vehicles remain a large unknown because there is so little information in the public domain. It is now more than 10 years since their first use was expected, which is why some observers think they never existed and others think they have been written off. It seems both not consistent with the kind of testimony from high level U.S. officials, and not in keeping with Russian determination to be a space leader to accept either of these viewpoints. Recently there have been reports of fresh work on the G pads at Tyuratam and the best guess now is that one of these days, we shall see a successful flight of a very large vehicle. After the troubles it has already experienced, one can imagine a possible redesign effort and also major steps to increase testing, reliability, and simplified operations to insure that so expensive a vehicle will do what is intended of it.

Additions to the vehicle stable

Studies by Western observers have suggested that in many instances there is a product improvement trend in Soviet launch vehicles which allows the upgrading of their capabilities over a period of time. But perhaps some existing models can be pushed only so far at reasonable cost and risk. Hence, some Western observers postulate that we shall see new additions to the known types. For example, many of the Western analyses of expected Soviet missions suggest that the D class vehicle is not quite equal to some useful missions, and a vehicle larger than D but not as large as G would be a useful gap filler both in Earth orbit and in deep space work. Until such a vehicle appears or its facilities are evident, considering the Soviet penchant for secrecy, it remains highly speculative to assume its certainty.

Use of high energy fuel in rockets

The Russians have not been in any hurry to move to high energy fuels as we understand them, because they had the early advantage of bigger capacity in their conventional rockets. Also, high chamber pressures were fairly typical so that they got quite a bit of performance from these engines. It is really a surprise that a decade behind the Americans, we have not had any good indication of Soviet operational use of hydrogen-oxygen combinations. In general, they are content to cluster large numbers of engines of moderate size as they need more thrust, relying on proven technology. Perhaps since they have not taken the fairly obvious and clean route to use of hydrogen and oxygen, it is even less likely that we shall see early Soviet use of hydrogen-fluorine, metallic fuels, or other exotic and toxic types.

Nuclear and electric rockets

There is no good evidence in the public domain to answer how vigorously the Russians are pursuing development of solid-core nuclear fission rockets, even though they are well aware of the possibilities and of previous U.S. efforts in this regard. One can assume that at least paper studies and breadboard engines have been tested, as in keeping with Soviet status as a leading space power. Soviet spokesmen of the caliber of Glushko have stressed the important place nuclear power can hold.

Electric rockets have a potential both for stationkeeping and for gradual acceleration on very long flights. Here there is more evidence that Soviet work continues actively in flight tests. Other volumes will give examples of several classes of flights which have included electric rocket systems. Those relying on solar cells provide measurable changes of orbit, but not very large increments of velocity. Future systems may do more but, to date, the full-scale fission type chain reactors have been employed only to provide electrical power for side-looking radar systems and not for electrical propulsion.

Reusable vehicles

The U.S. space program leaders recognized the development of a reusable Space Shuttle as a key step in putting the program on a long-term sustainable basis, pointing to the wastefulness of throwing away expensive hardware after brief use, and to the importance of providing a more benign environment to payloads so that design constraints could be eased, therby cutting costs.

Soviet space spokesmen also recognize the same logic and see reusability as the only way to go. Soviet incentives may be even greater because their level of activity is so much higher that the overhead costs of developing such a system would be sooner recovered.

There have been continued reports and denials of a program analogous to the American Space Shuttle, either D-launched or totally reusable, and there is some recent evidence that such a program may be advancing. Reports on such a program are difficult to evaluate because it could be quite late in the development process before there are overt signs of such a new system.

One of the most specific references came in a Moscow radio broadcast in English to North America.[140] The Soviet prototype was said to resemble an airplane, with delta wings and a cigarlike fuselage. The overall length would be around 200 feet, and its diameter with fuel containers around 26 feet. The design called for a specially designed launcher powered by rocket engines. However, speaking at a press conference during the International Astronautical Federation Congress in 1981, cosmonaut Yeliseyev stressed that the Soviets endeavoured to reuse the equipment but not the vehicle and planned to increase the cargo-carrying ability of the Progress spacecraft. He concluded, "At the present time, there is no plan for a Russian space shuttle." [141] The U.S.S.R. does not normally admit to new technological developments, especially to give details before they begin flying.

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[140] Moscow radio, 0001 GMT, June 11, 1978.

[141] Astronautics & Aeronautics.

A Chronology of Soviet Statements on Future Space Plans

This section discusses a moderately complete review of available "news despatches" (appendix I). All Tass bulletins referenced are from Moscow unless otherwise indicated.

In two previous studies prepared for the Senate covering the years 1966 through 1975, there were similar chronologies, and many of those items are still of interest.

The material is in chronological order of publication, grouped by years. Cosmonauts are frequently making forecasts, and one does not know to what extent they are privy to official timetables or when their own enthusiasms run ahead of reality. Most of the academicians who speak also head important bureaus within the space program so that their views reflect greater program responsibility than might be true of American academicians on the fringes of our social operations. In a few cases, important officials are labeled in pictures and write for journals under pseudonyms. (Maarten Houtman of the Netherlands has catalogued the names of about 6,000 space technicians and officials, and the true names of about 60 known by their pseudonyms. He has found what patterns are applied to selecting pseudonyms.) For example, Valentin P. Glushko, the Chief Rocket Engine Designer, wrote in the open as Georgiy V. Petrovich, and only recently has come into the open.

It must be remembered that some predictions which appear at more than one place in the chronology may have added weight for appearing several times, or it may be no more than a reflection that a one-time statement is reissued in a variety of publications in the absence of anything new to add.

Analysis of Soviet Intentions in Space

PACE AND TIMING

It is far easier to describe with some confidence the directions and the content of the Soviet space program than to be accurate in gauging the timing of such events. We recognize in the performance to date a mixture of elements or qualities which almost seem contradictory. On the one hand, there are many Soviet forecasts and promises of what they plan to do, and yet delivery on these promises seems to come very slowly to the impatient outside observer. Soviet manned flights during the period of the NASA Gemini and Apollo programs did not keep pace with the United States in number of flights or the level of achievement. Yet today they have an ongoing program, unfolding fairly steadily, even though lacking for the moment its manned deep space elements. Even with this slow movement, the total level of Soviet activity is running higher than the U.S. program did at its peak in 1966. Obviously the Russians stay very busy, even though most of the activity no longer rates much mention in ordinary newspapers in the West, leaving the public unaware of this progress. Despite the prosaic nature of much of this activity by today's standards, the Russians are still capable of surprising the public in any year with bold new steps. Their authorities seem to relish these surprises and if asked when certain developments are likely to come the stock answer is "when we are ready," which is not of much help to the forecaster.

Sometimes the cycle of Soviet development seems faster than that in the United States, but in high technology this is not always the case. It almost seems the Soviet lack of depth in advanced materials, some aspects of propulsion, in computer capacity, perhaps in some other aspects of electronics, stretches out development inordinately. The Soviet supersonic transport (SST) appeared very quickly after Concorde and seemed to borrow some of its design features, but introduction into revenue service has stretched out as has been true of the Concorde also. The fact the D class launch vehicle has not been used for a manned launch 15 years after its introduction when it seemed a natural for such use, points to troubles. The G class vehicle already has gone close to 13 years past the time it might have been expected to make a successful first flight, and the time is not remote when the project will be more than 20 years old since its probable inception.

Perhaps the important and enduring element is the seriousness and steadiness with which the Russians are adding to their space facilities and their space operations, building versatility and experience in depth. If they maintain the pace as they show every sign of doing, by the end of the century their space enterprises cannot help but be very formidable in the scientific, economic, and military sense. In the lifespan of nations this pace toward opening the solar system and applying technology to gain the benefits of space is close to revolutionary.

THE ENGINEERING LOGIC OF DEVELOPING SPACE APPLICATIONS

The Soviet Government has at its many levels, including the highest, men whose professional training has been in engineering and science. The specialists from the space field can make their case for concrete benefits from space development and have some confidence that their arguments will be quickly understood, tested, and accepted in terms of engineering logic. There may be less risk that an appeal to a higher level will be judged in comparison with other nontechnical programs but this is not known with certainty. The Russians may also have a procedural advantage in that they probably do not have to fund projects on an annual budget basis, which risks continuity of work. They are more likely linked to 5-year plans as the basic decision unit, and even longer term commitments can be made without the same threat of reversal with an early election. The political power in the U.S.S.R. is self-perpetuating in the sense that when new officials are to be elected, they are nominated by the people in power, and the vote is largely to ratify these decisions.

The Russian authorities have become convinced that use of space technology in support of work in meteorology, communications, navigation, and Earth resources is fully defensible in terms of the enhanced productivity of the national economy which will result. Even in the complete absence of national pride and prestige considerations, this work would still be well worth doing in terms of the economic benefits, some short term, others long term, and the investment is considered a wise use of capital.

One may argue whether a better engineering solution to Earth resources work lies in small, automated spacecraft or in large manned stations taking synoptic readings and bringing human judgment to bear in space rather than through remote controls on the ground. But this is a peripheral argument. Both approaches will work, and the decision becomes a broader systems problem which relates to total goals sought. The forecasts of practical applications to communications, weather, navigation, and Earth resources work in connection with space stations are almost always linked to plans for manned observatories looking outward and manned assembly stations to prepare ships for manned flight to the Moon and the planets.

Another area of space engineering applications is to military uses, and here, too, it seems clear that such work has been judged highly practical and immediate in the benefits returned. It is hard to imagine that the fragile world structure could have been held together through all the crises of recent years if the two major nuclear powers had not had a de facto open skies policy to keep each extensively informed about the rate of weapons progress and military deployment through space observations. President Johnson made this abundantly clear in his famous Nashville speech of 1967, and Konstantinov, the Vice President of the Soviet Academy of Sciences, made an equally explicit statement to this effect in his visit to Yugoslavia in 1968. It is these necessary military support services flights which make up the year in and year out steady work of the major space programs.

For the future, there continue to be new opportunities to enhance the military usefulness of space all in ways which are nonaggressive and in complete accord with existing treaties limiting the military use of space. The Russians can be expected to continue to exploit these opportunities. Finally, both space powers are cautious or realistic enough to know that, short of universal disarmament, the greatest threats to stability in international affairs would come from some new imbalance resulting from a one-sided technical breakthrough in military weapons and strategy. Hence, the Russians can be expected to press vigorously on these frontiers as much in self protection as in seeking their own advantage to insure the strength of their position in the world. This spurs development, lest they be left behind.

Additionally, Soviet space technology has already included two military developments the United States has not undertaken: The Fractional Orbital Bombardment System (FOBS), and the Inspector/Destructor Satellite series. Whether there will be more threatening moves beyond mere military support flights remains to be seen. A spaceborne missile defense system is one potential application which is tied to future developments both in reusable space shuttle craft and in laser weapons. Late in 1975, disclosures came that there was some evidence that ground-based lasers were probing U.S. military satellites in high orbit. An alternative explanation was that gas pipeline fires had been sensed. Although there have been no further reports of such activity it signalled the onset of the change destabilizing the previous relationship of live and let live in space which has seen the United States revive its ASAT plans and invest large sums in research into directed energy weapons systems.

INTEREST IN SCIENCE AND DISCOVERY

The Russians have been practical in recognizing the political merits of a strong space program and most of their effort of recent years has been concentrated on applied tasks to support the national economy and especially to support their military services. But Russia for all its alleged backwardness has a long tradition of interest in basic science, which has carried over into the Soviet state. The U.S.S.R. Academy of Sciences covers the range from practical to most basic research efforts, and this same spread is present in their space program. The academy enjoys a special position of power which exceeds the more peripheral and advisory role of the U.S. National Academy of Sciences. Hence, we can expect that there will be continuing support for study of basic geophysical, solar, and cosmological phenomena in space, as well as study of biology and medicine. Despite the lack of lunar activity since the Luna 24 mission in 1976, lunar and planetary studies will probably continue to hold government support and plans have already been announced for a fly-by of Halley's comet in 1986, a project now abandoned by the United States.

WILLINGNESS TO SUBORDINATE IMMEDIATE CONSUMER GAINS

Although some of the choices between putting the national economic product to work for consumers and for various capital and public interest projects differ from country to country, often the variances are governed as much by the economic and material conditions as by publicized ideology. For example, the United States builds much of its philosophy and practice around supplying goods for private consumption, and looks to participative private ownership of the means of production through large corporations with widely held stock. At the same time a large share of its total enterprise involves public financing of common services, including defense, welfare, provision of roads, and other public works. Also, many of the earnings of its private corporations are not paid out as dividends but are reinvested to further expansion of those enterprises. In Japan, the rate of reinvestment, as an alternative to direct private consumption, is very high indeed and accounts for much of the fueling of the remarkable Japanese economic growth machine both in advanced technology and in straight forward expansion. But even so, consumers in Japan have been close to universally equipped with color television sets, power washing machines, and refrigerators. Japan, as with the United States, has also acquired a considerable amount of pollution and urban blight.

In the Soviet Union there has been an explicit subordination of consumer welfare in the present order to build "Communism"—very much what used to be scornfully called "pie-in-the-sky" by Western labor agitators of an earlier age. Heavy industry has long enjoyed a priority over expansion of consumer goods and housing. When there are shortfalls in 5-year plans, they have tended more often to be in consumer goals than they have been in heavy industry. At the same time, the lot of the Soviet consumer has been substantially improved over the 1930's, the World War II period, and the earlier postwar years. Consumers know they are better off, and most of them do not realize they are behind the improvements of their own client states in Eastern Europe. But if their expectations rise sufficiently, the previous pace of capital investment, including work in space, might be risked in some degree.

Philosophically, however, there may still be a willingness to recognize a certain amount of psychic income provided to individuals from community expenditures as well as from direct private consumption. Just as the poor peasant in some countries may take pride in beautiful cathedrals, the Russian on a waiting list for a washing machine, a refrigerator, or a car, may still gain some meaningful benefits from handsome rapid transit systems, from extravaganzas in Red Square on May Day, and from the prominent accounts in Pravda and Izvestiya or on color postage stamps that show how the Soviet Union is exploring the cosmos. Already accepting the concept of personal denial in the present for Communist "pie-in-the-sky" later on, the space program as a long term investment may have better luck in the Soviet Union than it will in a Western society that wants personal goods and services in the immediate present and whose economists apply 10 percent discount rates to future benefits from space which may make it "objectively" unattractive to put capital into space systems that offer a poor return or investment.

FINAL CONCLUSIONS

The Soviet space program remains a strong, on-going enterprise. One cannot be certain about the future of any program. But as of now, there is every indication of a continuing commitment to maintain a high level of activity and investment in a long-term orderly development of space science and technology, and its use in Earth orbit, at the Moon, and at the near planets now (and later the whole solar system) for many purposes. This report does not prescribe an American response, which could include a mixture of reactions: Ignoring the Soviet actions and making our decision on their individual merits; bowing out and leaving the field to the Russians; matching them in the competitive sense and working harder for primacy; or negotiating various accommodations, divisions, and cooperative ventures. If this report has supplied a description and an interpretation of the Soviet program, then the implications of these data and reactions of our policymakers still are to be determined.

Chapter 2

Political Goals and Purposes of the U.S.S.R. in Space*

INTERNATIONAL SETTING, 1976-80: DISINTEGRATION OF DETENTE

CHANGING STRUCTURE OF INTERNATIONAL RELATIONS

MULTIPOLARITY, THE MAJOR TREND

The Soviets pursued their political goals and purposes in space during 1976-80 within a structurally familiar but rapidly changing international order.

Multipolarity had long supplanted the bipolar world that had been shaped by Soviet and American rivalry during the cold war years. The superpowers, with their awesome nuclear arsenals and virtually instantaneous delivery systems, still command center stage in world affairs; but the constraints and limitations on the use of that power, along with other factors, have diminished the political effect of their enormous military strength.

INTERNATIONAL TERRORISM, A NEW FACTOR

The spread of international terrorism, in some respects symbolized by Iran's seizure of the American hostages in the Teheran Embassy, introduced a new and perplexing element on the international scene, new in terms of its global dimension and impact, and perplexing because of the difficulties in coping with it. This act of violence dramatically revealed the limitations on the use of power in undertaking retaliatory actions. It revealed the impotence of superpowers under certain conditions beyond their control; for Iran showed the world that it could defy with impunity the most powerful nation in the world, abuse its diplomatic officials, humiliate its government and people—and, for a time at least get away with it without direct, prohibitive costs.

DIFFUSION OF POWER

The diffusion of power within the competing East-West blocs has continued to erode political control from the center. The effects have been to further weaken the power and authority of the superpowers as the principal actors in international affairs. No longer is it possible for them to maintain control and command the unquestioned loyalty of their allies. The emergence of Eurocommunism, the displays of unrelieved and open hostility between Peking and Moscow, and China's military invasion of the Vietnamese borderlands in February 1979, provide clear evidence of the deepening fissures within international communism and the extent to which national interest has supplanted ideology as a vital force in inter-Communist relations. Resistance by America's allies to any strong punitive action against Iran for seizing the American hostages and against the Soviet Union for invading Afghanistan (beyond the Olympic boycott) revealed the same tendency toward independence within the Western Alliance system.

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*Prepared by Joseph G. Whelan, Senior Specialist in International Affairs, Senior Specialists Division, CRS.

No longer do the superpowers have things entirely their own way.

TENDENCY TOWARD INTERDEPENDENCE

The spirit of nationalism has continued its forward surge in the Third World, regenerating the concept of the nation-state, globalizing its impact on the world system, sometimes stimulating a stronger tendency toward regionalism, and, in all, creating out of the Third World a formidable international force. The Third World can no longer be ignored by the great powers.

On the other hand, interdependence, a counter-trend, has become a clearly definable force in world affairs, diverting much attention away from East-West problems and redirecting it toward those between North and South. Problems of the international economy, pollution of the global environment, food distribution, limited resources and materials, access to ocean resources; problems arising from an exploding world population, international development, and to a lesser degree the management of outer space—all have been increasingly perceived as common problems requiring common solutions in the national interests of all. The emergence of the resource rich Third World and the impact of its political activism, using its newly acquired economic leverage (for example, oil), has quickened this awareness of interdependence and has added a new dimension to world politics as North-South problems compete for attention with those between East and West.

Though the Soviet Union has continued to view interdependence from its own distinctive conflictual world outlook, it, nonetheless, has become concerned about achieving its own particular interests. Discussions on global problems and interdependence have been undertaken by specialists within the academies and foreign affairs institutes, suggesting a Soviet awareness that they must take a serious look at global problems and prepare for the future as these problems impact upon the Soviet Union. Perhaps more important—since it determines world peace in which all nations have an interest—the Soviets negotiated and finally concluded the SALT II agreement with the United States, a major step to control the strategic arms race.

CONTINUING PROMINENCE OF SCIENCE AND TECHNOLOGY

Another element in the changing international structure has been the continuing prominence of science and technology both as creators of international problems and as vital components in their solutions through diplomacy. Rapid scientific and technological change, often at an exponential rate, has had a profound impact upon the world scene, complicating still further the tasks of diplomacy and magnifying the problems of management and control over the international environment. Advances in weapons technology, for example, have outstripped the skill of diplomats in their efforts to achieve negotiated limitations of modern armaments, to bring some dependable stablility to the strategic balance, and ultimately to increase the chances for world peace.

RISE OF THE ISLAMIC MOVEMENT

Finally, the rise of the Islamic movement has added still another new, and unpredictable, element in an already complex international order. This development is significant because the Islamic countries, lying within the Soviet-designated "national liberation zone" and partly along the Soviet border, constitute a large segment of the Third World. (The Soviet Union, with its rapidly growing Muslim population of some 45 to 50 million, ranks among the leading Muslim countries in the world.) Rich in oil resources and commanding strategic waterways of world communications, Muslim countries, notably those in the Middle East, bestride the most geopolitically important region in the world. Their importance has been heightened by their instability which has grown rather than diminished in recent years. The most recent case of a dangerous instability has been that of Iran.

Latent revolutionary Islamic forces erupted in Iran and by early 1979 had toppled the ruling Shah from his throne. Seizure of the American hostages later in the year, amid the disintegration of the country's political order and in open defiance of international law and diplomatic custom, sharpened the growing conflict between the Islamic leaders and the West and quickened the tempo of the revival of Islamic fundamentalism. The Soviet invasion of Muslim Afghanistan in December 1979 catalyzed still further the Islamic movement, unifying the Islamic countries in a common purpose; namely, to protest and condemn the Soviet invasion.

An Islamic revival of this dimension and with this impact was unexpected; its implications have yet to be fully understood; it is an unpredictable and potentially powerful force in international life today.

Such were some of the major elements in the structure of international relations during the last 5 years.

SOVIET-AMERICAN RELATIONS: TRENDS AND CHARACTERISTICS

MAIN THRUST OF RELATIONSHIP: TO MAINTAIN DETENTE

During the period under review, Soviet-American relations seemed to be directed along one main line: To maintain detente—that is, until the Soviet invasion of Afghanistan in December 1979. Since the invasion, detente has been tested as never before since its inception in 1972, with the signing of SALT I. With the passage of time Afghanistan seems more and more to have taken on the appearance of a watershed in Soviet-American relations, though this judgment must remain an open question. Nonetheless, despite Afghanistan both nations seem to have tried at least to keep the SALT process alive and to maintain a tolerable level of diplomatic civility. In a climate of fear, suspicion and tension—and on the American side, of a feeling of having been deceived—this has been no small accomplishment.[1]

But the course of detente has never really run very smoothly. Deep political and ideological differences have always lain at the base of this relationship. Tensions had been eased visibly but momentarily in the twilight of the Nixon administration. Successive Brezhnev-Nixon summit conferences provided a somewhat artificial stimulus to the expectation of an emerging new form of peaceful coexistence. The same was true in the early months of the Ford administration. The Vladivostok agreement, concluded in November 1974 and proclaimed a "breakthrough," established the framework for reaching a SALT II agreement. Nonetheless, the relationship remained adversarial and the strength of accommodation tenuous as disrupting actions by both sides buffeted the relationship.

Virtually by common consent SALT II had become the centerpiece of detente. Whatever measure of success or failure had been achieved in these negotiations, the results were inevitably reflected in detente. Disagreement over the Backfire bomber/cruise missile issue prevented success within the negotiating framework agreed upon at Vladivostok. Pressure on the Ford administration from the so-called "right wing" of the Republican Party during the primary election campaign in the spring of 1975, along with the adverse effects on detente of Soviet involvement in Angola, moved that administration to abandon the public use of the term "detente" and to mark time on SALT II negotiations. (The Soviets dropped the word "irreversible" in describing detente.)

Prospects of a SALT II agreement declined precipitiously with deepening Soviet involvement in Angola during 1975 and 1976. It continued to decline during the first 6 months of 1977 when the newly inaugurated Carter administration proposed to set aside the Vladivostok formula and press for deep cuts in the nuclear arsenals of the Soviet Union and the United States. At the same time the administration initiated an aggressive human rights policy that was directed initially at the Soviet Union. The Soviet reaction was hostile: It rejected the shift on the Vladivostok accord; it protested what it termed to be U.S. interference in Soviet internal affairs.

Toward the end of 1977, however, negotiations were resumed as relations improved, at least superficially. SALT I, scheduled to be terminated in October according to treaty stipulations, was extended by common agreement. A new agreement on SALT was expected in 1978.

But agreement was not reached. Deadlock on numerous arms control issues continued as tension increased over Soviet military involvement in the Ethiopian-Somali war and as anxiety over the general Soviet military buildup and its consequences for the U.S. strategic position was aroused to new heights. This growing concern among some respected national security specialists elevated the problem to the level of a major national issue. Not until June 18, 1979 was the deadlock finally broken and the SALT II treaty signed. But doubts on the wisdom of the treaty persisted as a lively debate took shape within the ratification proceedings.

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[1] This section draws upon a number of chronologies prepared in the Foreign Affairs and National Defense Division of CRS: Inglee, William B. Soviet-American Relations in 1976: A Chronological Summary and Brief Analysis. Congressional Research Service, Library of Congress, July 26, 1977, 135 pp.; Cooper, William H. Soviet-American Relations in 1977: A Chronological Summary and Brief Analysis. Congressional Research Service, Library of Congress, Mar. 1, 1979, 192 pp.; and the Chronologies of Major Developments in Selected Areas of Foreign Affairs published by the House Foreign Affairs Committee covering the years 1978, 1979, and Jan.-Mar. 1980. Washington, U.S. Government Printing Office.

What hopes there had been for Senate passage of the treaty were dashed with the emergence of the Soviet brigade issue in September. Old anxieties over the danger of Soviet penetration of Cuba, lingering within the Nation's conscience since the missile crisis of 1962, surfaced in the country with reports of Soviet combat forces in Cuba. Linkage of this issue with passage of SALT placed the treaty in jeopardy.

But the final blow came in December with the Soviet invasion of Afghanistan. Deeply alarmed by the implications of this bold military aggression, the United States reacted quickly and vigorously. It shelved the pending treaty, undertook peaceful sanctions against the Soviet Union, and set into motion defense policies that would strengthen the U.S. military presence in the Middle East and Persian Gulf region and enable it to respond to any further Soviet aggression in this vital strategic area.

Nonetheless, despite the shelving of SALT both sides have officially acknowledged degrees of adherence to the terms of the SALT agreements. The United States has been forthright in pledging adherence, so long as the Soviets did the same; the Soviets have been more ambiguous but still supportive in their policy declarations. Both sides apparently want to keep the SALT process alive.[2]

The future of SALT, and thus the future of detente, seemed for a time to hang on the issue of Afghanistan. Meanwhile, as of this writing the United States maintains only minor Afghan sanctions against Moscow, hoping in that way to show its displeasure and, with some support of other countries and sustained Afghani resistance, to pressure the Soviet leadership into withdrawing from Afghanistan. The Soviet Union has been proceeding with great difficulty to pacify the rebels and to reestablish the authority of the Socialist regime. By the end of 1980 neither the United States nor the Soviet Union has succeeded in their chosen courses of action: The Western response in support of the U.S. approach has been perhaps only marginally successful (though the Muslim nations, acting on their own, have vigorously protested the invasion); and according to recent estimates, the Soviets, despite an extensive commitment of military forces, have failed to suppress the rebels and have become "bogged down" in Afghanistan. A broad spectrum of foreign policy observers foresee a period of prolonged tension in Soviet-American relations.[3]

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[2] Afghanistan: Soviet Invasion and U.S. Response. Issue Brief: IB80006. Afghanistan Task Force, Foreign Affairs and National Defense Division. The Library of Congress, Congressional Research Service, Dec. 22, 1980, pp. 22-24. For a survey of recent Soviet-American relations, see, Simes, Dimitri K. The Death of Detente? International Security, vol. 5, Summer 1980: 3-25, and in the same issue, see Pierre, Andrew J. The Diplomacy of SALT, pp. 178-197, a review essay of Strobe Talbott's book, "Endgame: The Inside Story of SALT II," with added commentary by the reviewer.

[3] U.S. Congress. House Committee on Foreign Affairs. Soviet Policy and United States Response in the Third World. Report prepared by the Congressional Research Service of the Li-

Continued

OBSTACLES TO A HARMONIOUS RELATIONSHIP

Distrust and fear: The roots of superpower rivalry

(1) From the Soviet perspective

Distrust and fear lay at the roots of the Soviet-American relationship. Perhaps more than any other element these psychological characteristics have been responsible for producing the discord that has plagued the relationship ever since the Bolshevik Revolution 63 years ago.

On the Soviet side, distrust and fear are parts of an inherited national trait of insecurity that since the emergence of Russia as a European state centuries ago has permeated the Russian outlook in foreign affairs.[4] This trait had its origins in the geography that established the natural limits and the unique physical characteristics of the country, in the evolving political institutions that governed its people, and in the history of its national experience.

Vulnerable in Europe as the result of easy access of hostile forces across the Polish plain, Russia has been the victim of many enemy invasions throughout its history, the most recent large-scale invasions being by France under Napoleon and by Germany under Kaiser Wilhelm and Adolf Hitler. Such traumatic national experiences made a permanent mark on the history of Russia and its people, creating within the nation's psyche a sensitivity to its security and an awareness of its geographic vulnerability.

Historically, Russia's political institutions, authoritarian and absolutist and thus lacking the sanction of popular approval, instilled in its leadership, whether Czarist or Soviet, a distrust of potential enemies from abroad and from their own people within. The multinational character of the state, having been built upon the conquests of contiguous neighbors of different ethnic origins and cultures (a "prisonhouse of nationalities," Russia has been called), added to this heritage of distrust and suspicion.

The effect of these different elements was to produce in Russia, and particularly within its political leadership, a profound sense of insecurity. In the course of history this feeling of insecurity was transformed into a fear and distrust of the foreign, be it of people, things, or ideas, and even a fear and distrust of their own people, and it became a central feature in the Russian outlook on world affairs.

In the Soviet period a new ingredient was added; namely, communism. Essentially adversarial in behavior and messianic in belief, communism presumed a hostile relationship with the rest of the non-Communist world and fostered a belief in its ultimate Communist triumph as a world system—a militant, aggressive "savior" of mankind, so to speak. The combination of these elements, reinforced by Soviet experience during and after the 1917 Revolution and World War II, was to create a caste of mind preoccupied with

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brary of Congress. 97th Cong., 1st sess. Washington, U.S. Government Printing Office, March 1981, pp. 84-116.

[4] For an analysis of Russia and the problem of security, see, U.S. Congress. House Committee on Foreign Affairs. Soviet Diplomacy and Negotiating Behavior: Emerging New Context for U.S. Diplomacy. Prepared by Dr. Joseph G. Whelan, Senior Specialist in International Affairs, Congressional Research Service, Library of Congress. Washington, U.S. Government Printing Office, 1979, pp. 517-519.

insecurity. Subsequently expanding circles of conquest enlarged the security requirements of the Soviet state, placing new demands upon its people, resources, and political leadership and creating new anxieties for its security with each outward thrust. Russia's suspicions and fears were accordingly magnified by this process of expansion and growth of power.[5] It is not out of character, therefore, that Moscow's officially declared justification for the military invasion of Afghanistan, as it had been for Hungary and Czechoslovakia, was security of the state.

(2) From the American perspective

On the American side, distrust and fear of Russia have been emotions experienced strictly in the Soviet period. By and large the United States maintained a friendly and stable relationship with the Russian Imperial Government before the Bolshevik Revolution. Americans of the 19th century were an isolated people, protected within the Atlantic community as a byproduct of British seapower and far removed from the troubles of Europe. Their favorable view of Russia did not arise from any hidden virtues that they might have seen in the country or its people. Rather it sprang from national interest as perceived by both sides, for Russian and American interests generally coincided in international affairs. Ironically, in moments of national peril the Russians were on the American side, as in their support for the Federal cause in the Civil War and their participation in World War I on the side of the Allies. Nevertheless, Americans had disdain for Russia's autocracy and frequently complained officially of its violations of human rights. And the Russian aristocracy had equal disdain for American democratic institutions, an attitude difficult for them to conceal.[6]

Not until the Bolshevik seizure of power in Russia and the proclamation of their universal program of Communist conquest over world capitalism, with the United States as the principal target, did distrust and fear govern the U.S. attitude toward the Soviet Union. The "Red Scare" of the early 1920's, during which the civil liberties of suspected subversive leftists were hardly respected, revealed America's exaggerated fear of communism.

Not surprisingly, it took 16 years before the United States would establish diplomatic relations with Moscow, and even then it insisted that a series of Soviet pledges of good behavior be included in the official documents of recognition. Suspicion of Soviet good faith in fulfilling the obligations of recognition was an underlying American assumption in the entire proceeding. Beneath this suspicion was fear for the vulnerability of American institutions against the onslaught of subversive communism.

Fighting as allies in World War II against a common enemy failed to dispel American distrust and fear of Soviet Russia. Wartime negotiations were plagued by suspicion on both sides as each (the Americans late in the war) saw in the other motives of selfaggrandizement in the conduct of the war and in the diplomacy of the emerging postwar world.[7]

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[5] Ibid., pp. 518–519.

[6] The attitude of Sergius Witte, the Russian negotiator at the Portsmouth Peace Conference ending the Russo-Japanese War, toward the United States is discussed in, House Foreign Affairs Committee, Soviet Diplomacy and Negotiating Behavior, pp. 34–41. For [illegible] commentary on converging Russian-American interests in historical perspective, see pp. 539–[illegible].

The onset of the cold war generated perhaps the strongest feelings of distrust, a feeling that magnified with the advance of communism in the postwar period. The contest became global, as the cold war enveloped the world, dividing it into two hostile camps. The "Red Scare" of the 1920's was to be repeated with the rise of "McCarthyism" in the 1950's. And in Russia, Stalin initiated virtually a "reign of terror" that created within that nation a paralysis of fear and a siege mentality directed against "enemies" from within and abroad.

Armed with nuclear weapons and virtually instantaneous delivery systems, the superpowers, as they came to be called in the 1960's and 1970's, engaged in their global rivalry with undiminished intensity. Survival, the ultimate national interest of any nation, became in a very real sense the vital concern of both sides, for each possessed the power to destroy the other. Distrust and fear were the guiding spirit as each sought accommodation of its interests in negotiations, notably in the SALT process; for neither could trust the other and their mutual fears of destruction became a common characteristic of life in the nuclear age.

To expect such deep-seated primal emotions as fear and distrust to dissipate in Soviet-American relations is perhaps too great an expectation, too utopian. Clearly, given the powerful forces at work in international relations today—political and historical, technological and psychological—the odds are against it.

Conflicting ideologies and political perspectives

(1) Soviet commitment to revolutionary change

(a) Ideological differences.—Equally formidable as an obstacle to establishing harmony in Soviet-American relations is the conflict in ideologies and political perspectives. Where this conflict is most discernible is in their differing views on political change in the world and on such vital matters as human rights.

Briefly, the Soviets have a doctrinaire view of the world, of where it is going, and of their place within it. At least as a matter of state ideology, they see it moving inexorably toward socialism and ultimately communism, with the Soviet Union in the vanguard leading the revolutionary forces. For them this movement is preordained by history, and its success assured, driven on toward this goal by a dynamic and unfailing dialectical process working within the forces of history. The Soviets look upon their doctrine as an infallible design for the salvation of mankind. Change is inevitable; it is revolutionary, though not necessarily resulting in war since allowances are made for peaceful acquiesence by adversaries.

Viewing world affairs from the democratic perspective, Americans acknowledge the inevitability of change, but perceive it more in the context of peaceful accommodation of interests than in one of inevitable revolution. Tolerant of differences and conflicting interests, this view, though preferring democracy, having been a product of 18th century rationalism and belief in the rights of man, nevertheless accepts political pluralism as a fact of international life, believing that man as a rational being can resolve his differences and establish an acceptable harmony of interests. Recent history suggests that the Soviet view is clearly utopian; the American, overoptimistic.

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[7] For examples of concerns on both sides, see, House Foreign Affairs Committee, Soviet Diplomacy and Negotiating Behavior, chs. 4 and 5.

Both principles and the perspectives they produce clash, and when the adversaries are powerful nation-states like the United States and the Soviet Union, the repercussions can be far-reaching, as indeed they have been. For political beliefs, combined with the realities of power and driven on by a dynamic spirit of messianism, are the stuff that conflicts are made of.

(b) Kennedy and Khrushchev: Conflicting perceptions of the balance of power concept.—Two examples illustrate the force of these conflicting world views, notably over the limits of change, and their impact on Soviet-American relations: One deals with the Berlin crisis of 1961; the other with Soviet support for revolution in the Third World.

In the negotiations at Vienna in June 1961 between President John F. Kennedy and Chairman Nikita S. Khrushchev, the President tried to persuade the Soviet leader to accept the world balance of power as it existed in the belief that with recognition by each side of the other's interests and with the conduct of relations on that basis, a durable and genuine peaceful coexistence might be established. The background of the conference was Khrushchev's threat to Western rights in Berlin. Acquiesence in his demands would have meant Western recognition of a shift in the European power balance, a shift the Western powers were clearly not willing to accept, for Western vital interests were deeply enmeshed in the existing equilibrium of power.

As an historian and member of that generation much influenced by the consequences of appeasement in the 1930's, President Kennedy accepted the balance of power theory as a valid and realistic concept in international relations. His behavior during the crisis in Berlin, and later in the Cuban missile crisis, and his perception of the Soviet leadership and its policies was greatly influenced by this belief. Downgrading ideology, Kennedy tended to view international conflict more in national than in ideological terms. For him, national interest was the primary motivating force, not ideological abstractions.[8]

Thus, at Vienna, Kennedy tried hard to reach an accommodation with Khrushchev that would satisfy the vital national interests of each nation. The key element in his negotiating position was a mutual acceptance of the existing equilibrium of power and thus a common perception of the status quo—in brief, agreement on the limits of change that affected each nation. Kennedy accepted social change as part of the normal historical process, but essentially peaceful change and change that did not involve the prestige or commitments of the Soviet Union and the United States or upset the balance of world power. He recognized the status quo as acceptance of the existing balance of international force, but far from advocating a freeze on the social mold of the world, he believed in political and institutional change as both inevitable and desirable. What Kennedy hoped for was agreement on a process of change that would not entail the transfer of power from one bloc to the other and would not make either side feel threatened and therefore obliged to resist change by force.

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[8] This section draws upon House Foreign Affairs Committee, Soviet Diplomacy and Negotiating Behavior, pp. 329–330.

Khrushchev rejected Kennedy's perception of the balance of power concept, arguing the thesis set forth in his January 6, 1961 speech; namely, that social revolution, as a global phenomenon, was preordained by history; that such revolutions, that is, "wars of national liberation," were "sacred"; and that the Soviet Union had an obligation to assist whenever possible. For Khrushchev, the status quo meant the unimpeded progress of the conquest of power by Communist revolution on a global scale. Kennedy's conception of a global standstill was in his view an attempt to alter the status quo, not support it; it was an attempt to arrest the revolutionary process.

Thus, the conflicting perceptions of the balance of power concept and its implications for the status quo became entangled in Soviet-American relations, dangerously so because it meant that Soviet support for global revolutions (for example, Castro's revolution in Cuba) and refusal to recognize an acceptable balance of power (for example, in Berlin and thus Europe) would expose the great powers to the very miscalculations and confrontations that Kennedy sought to avoid. Out of this essentially ideological conflict of world views emerged the dynamic forces that produced the crisis in Berlin during 1961, and 1 year later, the Cuban missile crisis.

(c) Soviet support for revolution in the Third World.—More recent is the example of Soviet intervention in Angola and the reaffirmation of its commitment to revolution in the Third World. What is revealed here is again the conflict over the limits of change.

The United States had hoped that the Soviet commitment to detente would have placed restraints on their revolutionary activity in the Third World. But this was not the case. Like his predecessor, Leonid I. Brezhnev, General Secretary of the CPSU, rejected what for him amounted to acceptance of a status quo in the Third World and thus a denial of the Soviet role in the dialectic of history. Furthermore, he rejected any notion that support of the revolutionary "national liberation movements" contradicted the principle of detente.

The Ford administration protested Soviet intervention in Angola, warning that detente could not take another Angola. The Soviet response was best expressed in Brezhnev's report to the 25th Congress of the CPSU in February 1976. Perceiving a further upsurge of the revolutionary spirit in the Third World and a "deepening of the crisis of capitalism"—and thus the opening up of new opportunities—Brezhnev reaffirmed Soviet policy of support for the national liberation movements. Soviet relations with the liberated or developing countries "have expanded and become more lasting," he said. The political content of "our ties has become richer." Despite difficulties, "profound progressive changes are taking place" within the Third World; "the class struggle is intensifying"; its influence in world affairs has increased "appreciably." The Soviet attitude toward "the complex processes" in the Third World was "clearcut and definite." Brezhnev explained:

> The Soviet Union does not meddle in the domestic affairs of other countries and peoples. Respect for the sacred right of each people and each country to select their own road of development is a firm principle of Lenninist foreign policy. However, we do not hide our views. In the developing countries, as everywhere, we are on the side of the forces of progress, democracy and national independence, and we treat them as our friends and comrades-in-arms. Our party is rendering and will render support to peoples who are fighting for their freedom. The Soviet Union is not looking for any benefits for itself, is not hunting for concessions, is not trying to gain political supremacy and is not seeking any military bases. We are acting as our revolutionary conscience and our Communist convictions permit us.

Thus Brezhnev renewed the Soviet ideological commitment to revolutionary change.

"New horizons" were opening, especially in the Third World. And yet possible contradictions between this policy of support for revolution and the principle of detente were disallowed. "Detente does not in the slightest way abolish, and cannot abolish or change the laws of the class struggle," Brezhnev said, adding with a certain sleight-of-hand in his logic, "We do not conceal the fact that we see detente as a way to create more favorable conditions for peaceful Socialist and Communist construction. This merely confirms that socialism and peace are indivisible." [9]

That the Soviet commitment to—indeed active support of—revolutionary change in the Third World acts as a formidable obstacle to harmonious relations with the United States is evident by the repercussions of its military involvement in Angola, the Horn of Africa, and most recently Afghanistan.

Both illustrations—the conflicting Kennedy-Khrushchev perceptions of the balance of power concept and the Soviet commitment to revolutionary change in the Third World—point up, therefore, the irreconcilability between the Soviet and American view of political change in the world and clarify how the conflict in ideology and political perspectives can create formidable obstacles to a harmonious Soviet-American relationship.

(2) Conflicting views on human rights

(a) Emphasis of Carter administration on human rights.—Equally important with the conflicting perceptions of change in world affairs is the differing Soviet and American views on human rights. This issue is important because the Carter administration made human rights a cardinal principle of its foreign policy and, especially in its early years, had directed much of its criticism for violations at the Soviet Union. Consequently, much of the tension in Soviet-American relations, particularly since the inauguration of the Carter administration in January 1977, was caused by the human rights issue.

(b) International documents on human rights.—Human rights has been an issue in Soviet-American relations because each side views and acts upon the matter from conflicting ideological perspectives. Formally human rights as an international concern rests upon several documents, two of which are: The U.N. Universal Declaration of Human Rights of 1948, and the Final Act of the Conference on

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[9] Ibid., pp. 431–434.

Security and Cooperation in Europe at Helsinki in 1975. Both documents are not legally binding but rather represent a statement of principles. Adherence by many of the world's nation-states, nonetheless, invests in them considerable moral force. Some of the relevant articles in the Declaration of Human Rights are as follows:

> *Article 1*—All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood.
>
> *Article 3*—Everyone has the right to life, liberty and the security of persons.
>
> *Article 9*—No one shall be subjected to arbitrary arrest, detention or exile.
>
> *Article 13*— . . . 2. Everyone has the right to leave any country, including his own, and to return to his country.
>
> *Article 18*—Everyone has the right of freedom of thought, conscience and religion; this right includes freedom to change his religion or belief, and freedom, either alone or in community with others and in public or private, to manifest his religion or belief in teaching, practice, worship and observance.
>
> *Article 19*—Everyone has the right to freedom of opinion and expression; this right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers.[10]

The Helsinki Final Act reaffirmed the purposes and principles of this Declaration and the United Nations Charter in the field of fundamental human rights and freedom. Among the statements on human rights set forth in the Declaration on Principles Guiding Relations between Participating States are the following:

> The participating States will respect human rights and fundamental freedoms, including the freedom of thought, conscience, religion or belief, for all without distinction as to race, sex, language or religion.
>
> They will promote and encourage the effective exercise of civil, political, economic, social, cultural and other rights and freedoms all of which derive from the inherent dignity of the human person and are essential for his free and full development. . . . The participating States recognize the universal significance of human rights and fundamental freedoms, respect for which is an essential factor for the peace, justice and well-being necessary to ensure the development of friendly relations and co-operation among themselves as among all States.

(c) Conflicting interpretations: The American view.—Both the United States and the Soviet Union concurred in the adoption of these important international documents setting forth what appear to be common principles on human rights. However, the difficulty arises from the conflicting interpretations that each has given to these principles. In this case, "truth," like beauty, lies in the eyes of the beholder.

Soviet and American interpretations derive largely from contrasting ideological beliefs that shape their thinking, produce some antithetical goals, purposes, and national values, and ultimately place them far apart on the political spectrum.

American democratic ideology is rooted in the Declaration of Independence, the Constitution, the Bill of Rights, and the political philosophies of Locke, Jefferson, and Madison, and shaped by its unique historical experience. This ideology glorifies the rights of men as individuals within a genuinely democratic society with a modified free market economic system. It lays down the principle of individual human freedom as one of the highest attainable human values; it places man in the center of its political universe, endows him with a system of law to protect and preserve his rights and property and provides a system of government where power and authority flow from the governed.

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[10] This section draws upon Whelan, Joseph G., Human Rights in Soviet-American Relations. Washington, Library of Congress, Congressional Research Service, May 8, 1978 (Issue Brief IB 77031-Archived).

(d) Conflicting interpretations: The Soviet view.—Soviet ideology is rooted in the thought of Marx, Engels, Lenin, and Stalin, and shaped by the equally unique Russian and Soviet historical experience. A capitalist economic system in this view must inevitably violate the economic rights of most people. Extremes of wealth and poverty in the West are seen as clear evidence of this. Freedom is interpreted in a larger social and collective sense where the interests of society and state take precedence over those of the individual and where the limits of freedom are laid down by a small autocratic ruling elite. This elite, functioning within a tightly closed and rigidly organized totalitarian system, undertakes to act in the interests of all.

Political democracy is held in anathema, simply reflecting the needs of a capitalist ruling class, and according to the Marxist-Leninist laws of history, it is doomed to destruction. The party and the state, subsuming the individual man, are the center of the Soviet universe; law is the protector and preserver of the collective well-being, not of any inalienable rights of the Soviet citizen; and power and authority flow from the elite leadership, not from the governed.

(e) Inevitability of conflict.—Accordingly, Americans see the suppression of human rights in the Soviet Union as libertarians from an open democratic society understand them; namely, as the denial of fundamental and inalienable rights of men to act according to a free conscience and to exercise a maximum feasible freedom of choice.

The Soviet leaders perceive selective suppression as a "sacred duty" because internal dissent represents a threat to the doctrinal validity and integrity of the socialist system and the security of the party, the Soviet state and its people. They reject U.S. protests on grounds that it is interference in the internal affairs of the Soviet Union. Brezhnev gave this explanation in an address before the Soviet Trade Union Congress on March 21, 1977, which elucidates the Soviet perception of dissent:

> In our country it is not forbidden to think differently from the majority. We regard the comrades who come out with wellfounded criticism, who strive to help the cause, as critics in good faith, and we are grateful to them. Those who criticize erroneously we regard as erring people.
>
> It is another matter when several persons who have broken away from our society actively come out against the socialist system, embark on the road of anti-Soviet activity, violate laws and, having no support inside the country, turn for support abroad, to imperialist subversive centers.
>
> Our people demand that such so-called public figures be treated as opponents of socialism, as persons acting against their own motherland, as accomplices and sometimes agents of imperialism. Quite naturally we have taken and will take measures against them as envisaged by law.
>
> And, in this matter, let no one take offense. To protect the rights, freedoms and security of 260 million Soviet people from the activities of such renegades is not only our right, but our sacred duty.

Soviet resentment against U.S. complaints of Soviet violations of human rights, as understood by Americans, has been bitter and strong. Here is what Brezhnev said to the assembled Soviet trade unionists:

> Washington's claims to teach others how to live, I believe, cannot be accepted by any sovereign state, not to mention the fact that neither the situation in the United States itself nor United States actions and policies in the world at large give justification for such claims. I will repeat again: we will not tolerate interference in our internal affairs by anyone and under any pretext. A normal development of relations on such a basis is, of course, unthinkable.

(f) Impact of conflicting interpretations.—This mismatch in perceptions of human rights has inevitably increased discord in Soviet-American relations. President Carter's vigorous pursuit of his human rights policy in the first year of his administration provoked an equally vigorous response from the Soviet side. American protests of Soviet violations went unheeded as the Soviets proceeded to arrest, bring to trial, and imprison some of Russia's leading dissidents. As a result progress on SALT was delayed, and the relationship as a whole took a decided downward turn. Not until both sides backed off on this issue did progress in the negotiations resume and the relationship achieve a measure of stability.

Deepening differences; broadening misunderstanding

To sum up, the point to be made here is simply this: The depth of the differences between the Soviet Union and the United States in ideology and political perspectives—differences fundamental in such matters as political change in the world and human rights—when combined with the distrust and fear that have existed for so long on both sides, altogether create a formidable obstacle to establishing a harmonious relationship. The Soviet invasion of Afghanistan was to deepen these differences and broaden the void of misunderstanding, for it was a dramatic portrayal of these basic elements in conflict being acted out in a practical, real world setting.

AFGHANISTAN: A CONTINUING PROBLEM IN SOVIET-AMERICAN RELATIONS[11]

Radical change in American perceptions

The Soviet invasion of Afghanistan was called a "watershed event" in international politics. Whether or not this initial assessment is correct still remains an open question. Hostile criticism of the Soviet action through 1980 has tended to become muted with the passage of time and as doubt and uncertainty, stimulated by reappraisals of interests, have set in during the aftermath of the invasion. This tempering of international concern, combined with the growing Soviet difficulties in Afghanistan, tends to cast some doubt on the correctness of this assessment.

Initially, the invasion had an alarming effect on the United States. The administration, shocked by this bold Soviet military thrust, took vigorous retaliatory actions to punish the Russians: It shelved the SALT II treaty temporarily; halted the sale of high technology and strategic items to the Soviet Union; restricted cultural, economic and scientific exchanges; and refused to participate in the summer Olympics in Moscow. Other countries, including those in Western Europe and the majority of the Muslim states, denounced the invasion, but for a variety of reasons few have been willing to take as strong a stand as the United States.

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[11] This section draws from House Foreign Affairs Committee, Soviet Third World Policy and U.S. Response, pp. 84-116.

What seemed to be the most significant result of the invasion was the serious impact it had on the American perception of their relations with Russia and more broadly on their perception of what position the United States should maintain in world politics. The Afghanistan crisis shocked both the administration and the American people, producing a radical reappraisal of U.S. foreign and defense policies and a decided shift in American public opinion.

The initial thrust and tone of the American response was decidedly "hawkish." Public opinion, sharply critical of Soviet policy and reflecting disillusionment about the future course of relations, took a downward turn from its formerly favorable attitude toward relations with Russia. The Nation seemed to be swept up in a new spirit of bellicosity. It was generally agreed that the "Vietnam syndrome," meaning "never again" will the United States become involved in a foreign war over less than vital national interests, had been dissolved, and that the United States was once again moving toward a policy of qualified or selective globalism.

When Soviet-American relations will get back on the track of the pre-Afghan days remained problematical at the end of 1980. As noted above, action on SALT II would seem to be a major test of intentions for both sides. Hints of a possible return to negotiations and perhaps normalcy surfaced with preliminary proposals on the Euromissile issue suggesting that negotiations could proceed without ratification of SALT and with an exchange of reassuring signals by both sides during the fall of 1980. Nonetheless, Soviet "pacification" of Afghanistan goes ponderously forward, posing a clear and present danger to the vital interests of the United States and its allies if Afghanistan becomes a base for further expansion of Soviet arms and influence in the critically important oil-rich regions of the Persian Gulf. Qualified foreign policy observers foresee a period of prolonged tension in Soviet-American relations. Afghanistan, therefore, remains an important issue in determining the future course of the relationship. Furthermore, uncertainty about Soviet intervention in the unfolding Polish crisis during the closing months of 1980 contributed to tensions in the relationship.

Afghanistan: A new direction for Soviet policy?

The Afghanistan issue raised a series of basic questions that inevitably affect the course of Soviet-American relations. Does the invasion represent a new direction for Soviet policy, particularly in the Third World? Is it the opening of a new era of Russian expansionism in which Soviet military power will become the principal instrument of policy? Or is this an aberration, an overreaction by Russia to historic fears for its security, the implications of which are more regional than global, more local than geostrategic?

Opinion has been divided essentially between two schools of thought, the offensive and the defensive. The offensive view perceives the invasion as a "qualitative" change in Soviet foreign policy; asserts that it represents the opening of a new era of Russian expansionism and territorial conquest; and holds that it thus constitutes a direct threat to the vital interests of the United States in the Middle East.

The defensive school tends to argue that the invasion was a response to real or imagined threats to Soviet security along its sensitive southern border. This border divides Russia's Muslims from their kinsmen in the Middle East and South Asia. The upsurge of the militant Islamic movement in this area has no doubt heightened Soviet concerns for its internal security. Soviet motives were thus more regionally directed, and less a direct threat to U.S. and Western geostrategic interests. Tending to see many constraints on Soviet expansionism, notably the limitation on economic resources, this school tends to downgrade the degree of threat to the United States and its allies.

The cases for both sides have been forcefully argued. But by the end of 1980 one fact seemed clear, and it was that the Soviets were more deeply committed—even "bogged down"—in Afghanistan and that this deepening problem, as a spoiler of the relationship, could not only adversely affect Soviet relations with the United States, but also temper Soviet expansionist ambitions, at least for the near future.

A Summing Up

Such was the international environment within which Soviet-American relations took place during the past 5 years. Multipolarity dominated world politics as a surging nationalism, especially in the Third World, catalyzed the diffusion of power and the devolution of authority. Interdependence in a world of many competing parts, and science and technology with their ambiguous promise of progress and retrogression, offered some elements of stability in a world system that was buffeted by international terrorism and by the spectacle of the revival of an unpredictable, militant Islamic fundamentalism.

Detente remained the declared objective of Soviet-American policymakers, but that hope was placed in jeopardy by their inability to repress the fear and distrust that lay at the roots of the superpower rivalry and to reconcile their conflicting ideologies and political perspectives. The Afghanistan issue, a classic case of ideologies and interests in conflict, deepened already profound differences and broadened the already expanding gap of misunderstanding in Soviet-American relations, so that both nations now face the 1980's, a dangerous decade by all accounts, with the SALT process in suspension, diplomacy somewhat debased, and prospects for the future clouded.

SOVIET POLITICAL USES OF SPACE

Patterns of the Past and Present

FAMILIAR THEMES OF THE PAST

Past studies in this series on Soviet space activities revealed that space exploration, though strictly a scientific and technological undertaking, has important political uses and that the Soviet Union, being fully cognizant of the value of space in international politics, has over the years seemed to have taken every opportunity to exploit space for political purposes and the advantages it could yield in foreign policy.[12]

Among some of the familiar themes of the past was the downgrading of American space efforts that was generally juxtaposed in Soviet propaganda with efforts to magnify and often distort Soviet space achievements. The underlying purpose of this political tactic was to maintain and increase the prestige of the Soviet Union in the eyes of the world—prestige meaning a reputation for power, or the shadow cast by power. Soviet success in space was demonstrated proof of the perfectability and the superiority of the socialist system over that of the capitalist. In contrast with the United States, which the Soviets claimed sought to militarize space, the Soviet Union was always portrayed as carrying on space exploration for the purposes of peace and the benefit of mankind.

Within this pattern of the past, efforts were persistently made to identify Soviet space achievements with the Communist Party of the Soviet Union (CPSU) and the Soviet Government, meticulously emphasizing that both, notably the party, were the source of Soviet success. Soviet political leaders were accordingly featured prominently in efforts to maximize party linkage with space. The value and practical results of space exploration for the national economy were also emphasized in efforts to justify the cost both human and material that went into space exploration. Space scientists and cosmonauts became particularly convenient and effective political instruments for educating the Soviet people on space, justifying the extensive investment of resources, and advertising Soviet achievements at home and abroad.

In time a certain mystique and mythology seemed to take shape in the political rituals surrounding manned spaceflights from liftoff to subsequent official tributes to the cosmonauts in the Kremlin that in sum glorified the U.S.S.R., its institutions, people, leaders, and ideology and dramatically underscored the value of space exploration as a worthy enterprise.

SOME THEMES DURING 1976-80

Secrecy and style

A sampling of Soviet literature on space during 1976-80 suggests little variation from what has now become traditional themes and a confident style in Soviet space politics. Secrecy is absolute, and available information politically managed; the style reflects self-confidence and a "businesslike" approach to a very serious business, space exploration.

Secrecy remains the watchword in Soviet reporting on space, and thus effectively draws a curtain around public knowledge of Soviet space activities. Dr. Charles S. Sheldon II, the American specialist on Soviet space activities, drew the following comparison with NASA that, while dealing specifically with information made public at launchings, nonetheless, suggests the character of Soviet secrecy in virtually all respects of their space programs:

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[12] For the most recent study on Soviet space politics, see, U.S. Congress. Senate Committee on Aeronautical and Space Sciences. Soviet Space Programs, 1971-75: Goals and Purposes, Organization, Resource Allocations, Attitudes Toward International Cooperation and Space Law. Staff Report. Washington, U.S. Government Printing Office, 1976, vol. II, pp. 27-63.

> The NASA (civilian) part of the U.S. program is generally run on a very open basis with the press at launches and most questions about flights answered both before they occur and after they are over. There is less openness in the Department of Defense space launchings, most which are not given names or purposes, advance notice, or published results.
>
> The Soviet Union holds to a minimum advance notice of flights, limits information on the bulk of their flights, but at least makes a prompt announcement, assigns a name, and gives orbital parameters for all flights which are successful in reaching some kind of an orbit which looks reasonable. All are described as scientific in purpose and successful in some degree. While a reporter in the United States can query NASA for more details of NASA flights, reporters rarely are able to gain elucidating details through questioning Soviet officials about their flights.[13]

The tone of such Soviet announcements on space is very matter-of-fact and professional.[14] Gone is the excessive, heavy-footed propagandistic style that was characteristic early in the Space Age. To be sure the Russians make their political points, but they do so seemingly with more finesse and subtlety. This change in style reflects the serious, "businesslike" approach of the Brezhnev leadership in the conduct of its international relations. But it also reflects a growing sense of self-confidence among the Russians that they have come a long way since the launching of Sputnik over two decades ago and that they have good reason to be proud of their accomplishments in space and sure in the direction their programs are going.

Political use of cosmonauts

The Soviets continue to prominently display their cosmonauts abroad as political spokesmen for their country. The effect of this device is to link their celebrity with particular political ideas and policy lines then being advocated by Moscow or with long-held ideological assumptions and historic Communist traditions. At the invitation of the British Communist Party, Valentina Nikolayev-Tereshkova led the Soviet delegation in October 1977 to London to commemorate the 60th anniversary of the Bolshevik Revolution. At a press conference the world's first woman cosmonaut stressed the common bonds of friendship and solidarity between the CPSU with the British Communist Party and "the working people of the two countries" that have existed since the Bolshevik Revolution. She expressed her pleasure in having heard while in London "very many kind words and appreciative remarks addressed to the Soviet Union for the enormous contribution it is making to mankind's struggles for lasting peace, for effective international detente and for the developing and deepening of mutual understanding among the nations." Tereshkova is a member of the CPSU Central Committee and chairman of the Soviet Women's Committee.[15] Since her spaceflight in 1963, she has been actively engaged as an ambassador-of-goodwill for her party and government. Tereshkova has been especially active among international women's organizations.

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[13] U.S. Congress, House Committee on Science and Technology. United States and Soviet Progress in Space: Summary Data Through 1979 and a Forward Look. Report prepared by Dr. Charles S. Sheldon II, Senior Specialist in Space and Transportation Technology, Science Policy Research Division, Congressional Research Service, Library of Congress, for the Subcommittee on Space Science and Applications. Washington, U.S. Government Printing Office, April 1980, p. 31.

[14] The announcement over Moscow Radio on the termination of the Salyut 4 flight illustrates the matter-of-fact, professional style of the Soviets. The broadcast simply states the fact of the termination of the flight. It gives the specific facts on the date of launching and notes that two expeditions of cosmonauts worked on the station for 93 days. It describes briefly the procedure for bringing down Salyut 5 above the target region in the Pacific Ocean. In one paragraph the announcement summarizes the purpose of the flight in which Cosmonauts Gubarev and Grechko and later Klimuk and Sevastyanov carried out prescribed research programs aboard the station. The statement noted the successful accomplishment of the flight of Salyut 4 lasting more than 2 years and concluded with this subdued commentary on its success: "The results obtained are of great importance and are being successfully applied in the interests of the economy, science and the further improvement of space technology." (Moscow Domestic Service in Russian, 1530 GMT, Feb. 3, 1977, FBIS 47.)

Cosmonaut German Titov, head of the Soviet-Vietnamese Friendship Society, performed his role as a prestigious spokesman to reinforce the Hanoi-Moscow political relationship. This connection has been especially important to Soviet policy in Southeast Asia, where since the American withdrawal from Vietnam it has sought to expand its preeminent influence. By expressions of friendship, gratitude, and political support on such occasions as the Vietnamese national holiday and the Vietnamese Lunar New Year, Titov demonstrated Russia's deep and continuing concern for its important Asian ally. Titov reminded the Vietnamese that the "lifegiving" source of their friendship has been "the immortal ideas of Lenin and the Great October Socialist Revolution" without which "the people of Vietnam would not have carried out their August revolution." In commemorating the Lunar New Year, Titov pledged that, "Now, as during the war, the land of the October Revolution always remains beside you. You can always rely on the Soviet people's support and assistance." [16]

Joint flights of East European cosmonauts with their Soviet colleagues became occasions for triumphal visits and laudatory expressions on mutual friendship, solidarity, and support for common policies. A particular case in point was that of Czech cosmonaut Vladimir Remek's participation in the Soyuz 28 flight that docked with the Salyut 6 space station in March 1978. At a commemoration of the successful Soviet-Czech flight (a first for the Czech's) in Prague during May 1978, Jozef Lenart, the Czech Communist leader, greeted the "five space brothers" (Vladimir Shatalov, head of the Yuriy Gagarin Space Center, and cosmonauts Aleksy A. Gubarev, Romanenko, Grechko, and Remek); voiced "our great gratitude" to the Soviet people, Brezhnev their leader and the Soviet scientists; expressed pride in the role played by Remek; hailed the Interkosmos program and the Czech contribution to it as an example of the internationalization of science; and underscored the relevance of the development of space science to the national economy—a basic justification persistently proclaimed by the Soviets. In a broadly gauged political statement, Lenart seemed intent on reinforcing Prague's relations with Moscow, gravely damaged by the intervention of 1968, when he exclaimed amid the applause of his audience:

> By this flight, socialist countries have shown the world that the development of the national economy and the growth of the wellbeing of the people are the basic interests to which we want to subordinate all scientific, research and production potential. This is why our people speak so resolutely against the next round of the arms race which the American military-industrial complex wants to start. This is why we are against the neutron bomb, against the fact that socialist countries

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[15] Soviet News, Nov. 1, 1977, p. 380.

[16] Moscow Tass in English, 1801 GMT, Aug. 30, 1977, in FBIS Daily Report: Soviet Union, vol. 3, Aug. 31, 1977, p. L1, and Moscow Radio in Vietnamese to Vietnam, 1000 GMT, Feb. 7, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Feb. 9, 1978, p. L6.

> would be forced to produce it. We do not want to focus the skill and creativity of our scientists on destruction but on the creation of new values for a happy life of mankind on earth.[17]

And as customary when in orbit Soviet cosmonauts continue to dutifully report to Brezhnev on the accomplishment of their mission and use the occasion to reaffirm their pledge of Communist fealty and to convey expressions of socialist patriotism. Thus on February 23, 1977, cosmonauts Col. Viktor Gorbatko and Lt. Gen. Yuriy Glazkov sent the following message to "Dear Leonid Ilich" from Salyut 5:

> On the glorious anniversary of the Soviet Army and Navy we ask you to accept from the crew of Salyut 5 the warmest and most cordial congratulations. From the bottom of our hearts, Dear Leonid Ilich, we wish you good health and new achievements in your tremendous activities for the benefit of the Soviet people and in maintaining peace throughout the world.
>
> We report to you that the program of work on board the Salyut 5 station has been fulfilled in its entirety. We would like to dedicate this flight to the forthcoming 60th anniversary of the Great October Socialist Revolution.[18]

Sevastyanov and Ursul: "Cosmonautics and Social Development"

(1) Scholarship, space, politics and propaganda

How space functions as a reinforcing agent in Soviet international politics is apparent in an article appearing in the November 1977 issue of International Affairs entitled, "Cosmonautics and Social Development." [19] Published in Moscow in many languages by the "All-Union ZNANIYE Society," International Affairs contains commentaries and analyses on foreign affairs by qualified Soviet specialists that are at once analytical within the limitations of Marxist-Leninist thought and official Soviet policy but flavored with political propaganda. Heavily politicized and nonacademic in the strictest sense, the publication is nevertheless intended for the serious general reader on the Soviet view of international relations.

The authors of this particular article are V. Sevastyanov, Cand. Sc. (Technology) and Pilot-Cosmonaut of the U.S.S.R., and A. Ursul, D. Sc. (Philosophy). The immediate background for the publication was the launching of the Salyut 6 space station on September 29, and Soyuz 25 on October 9, 1977. Soyuz 26 was launched on December 10. Eventually crews from Soyuz 26 through and including Soyuz 37 were to occupy the station by the end of 1980. The occasion for publication was commemoration of the 20th anniversary of the launching of Sputnik I and the 60th anniversary of the Bolshevik Revolution.

This article, approximately 6,300 words in length, is a comprehensive statement of the Soviet attitude toward space exploration placed within a political context. For the purposes of this study it constitutes a classic statement of Soviet observations, projections and assessments of their space activities whose underlying directed purpose is to gain political influence abroad. To illustrate this point, as well as the traditional themes in Soviet space politics and propaganda, excerpts from the article are quoted below within selected categories that are self-explanatory.

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[17] Prague Domestic Service, in Czech, 1930 GMT, May 2, 1978, in FBIS Daily Report: Eastern Europe, vol. 2, May 3, 1978, pp. D3-D4.

[18] Moscow Domestic Service in Russian, 1200 GAT, Feb. 23, 1977, in FBIS 29. It was especially fitting on this occasion for the cosmonauts to address Brezhnev as not only General Secretary of the CPSU Central Committee, but also by his military titles, Chairman of the U.S.S.R. Defense Council and Marshal of the Soviet Union.

[19] Sevastyanov, V. and A. Ursul. Cosmonautics and Social Development. International Affairs, November 1977: 70-77.

(2) Altruistic aims of Soviet space activities

> The development of Soviet cosmonautics fully and entirely accords with the principle recorded in the Programme of the CPSU: "Everything for the sake of man, for the benefit of man". Space studies in the USSR and other countries of the socialist community set the profoundly humane task of making outer space and space techology serve man. Space research has greatly expanded the horizons of scientific knowledge and brought about an intensive development of many branches of the national economy. Artificial earth satellites and other space vehicles have made possible long-distance radio- and tele-communications, precise weather forecasts and global cartography, and rendered effective the search for mineral deposits. Space exploration is accelerating and stimulating the scientific and technological revolution. (p. 72)
>
> * * * * *
>
> To utilize space and cosmonautics in the interests of mankind for the solution of major scientific technological and economic problems—this should be the aim on which man bases his activity in space. It is this approach to the problems of cosmonautics, providing for a combination of activity on earth and in space, for using cosmonautics for the good of man, that is a true alternative to the various bourgeois views on the prospects of conquering space.
>
> It would be wrong to set up an opposition between activity in space and on Earth or to absolutize the importance of one of them to the detriment of the other because achievements in space development have a beneficial effect on the economic development of the nation, while the march of social progress on Earth creates new potential for the further cognition of near-terrestrial space. Man's penetration into the Universe, his study and conquest of it are not a manifestation of his inability to cope with terrestrial problems, not a flight from them but a qualitatively new, often unique, means of resolving many of the pressing tasks of developing science, technology and economics. The development of space research in the USSR clearly and patently shows the prospect of using cosmonautics for the benefit of man that is revealed under socialism. (p. 75)

(3) Negative aims of "bourgeois" space activities

> Problems related to the mastery of outer space are constantly discussed in the Western technical, political and philosophical press. It is indicative that many bourgeois researchers, among them M. Born, A. Weinberg, V. Pickering, F. Hoyl, X. Shapley and L. Eiseley, are urging the scaling down or even termination of space studies. They contend that a further intensive and extensive development of cosmonautics can bring about only negative consequences for society, in particular, an increase in nonproductive spending to the detriment of the populations's living standards and the solution of its more pressing social problems.
>
> It is evident that the exponents of these views believe that it is not the nature of social relations existing in capitalist society but technical means themselves which constitute a factor that adversely influences social development. The authors of this concept negatively absolutize the achievements of cosmonautics and of science and technology in general.
>
> At the same time, representatives of the world of business and firms, with whom orders have been placed in connection with space exploration, profess diametrically opposite views. For them space exploration is a source of immense profit, and they distort the role of cosmonautics in the belief that the solution of many social problems, for instance unemployment, will depend mostly on its development.
>
> It is absolutely clear that in both instances we are dealing with views of an apologetic nature, which reflect overtly or covertly capitalist society's inability to direct the scientific and technical revolution for the benefit of man and society as a whole. At the same time, the appearance of such views points to the increasingly aggravating contradiction between the requirements of scientific and technical progress in an age of space exploration and the inability to utilize them in a full and conprehensive manner under capitalism. (p. 75)

(4) Source of Soviet space success: CPSU and Soviet Government

The accomplishments of Soviet cosmonautics have won international acknowledgement and convincingly demonstrate the potential created by the socialist system for scientific and technical progress. The Resolution of the CPSU Central Committee on the 60th Anniversary of the Great October Socialist Revolution says that "socialism has created limitless possibilities for developing science, and made it serve the people.... Soviet science has major achievements in the study of social development to its credit, and it has travelled to the most advanced frontiers in several directions in mathematics, mechanics, quantum electronics, solid-state physics, nuclear engineering, chemistry, biology, space research, Earth sciences and many other fields of knowledge". (p. 70)

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The development of theoretical and practical cosmonautics in the Soviet Union and the consistent fulfillment of most sophisticated space programmes are striking evidence of the advantages and potential of socialism. The very concern shown for K. Tsiolkovsky's heritage, which manifested itself in the tempestuous development of space technology, is irrefutable evidence of the CPSU's inspiring and stimulating role in the progress of cosmonautics. The creators of space technology in the USSR carried out their projects under the guidance of and thanks to the tireless concern of the Party, and regarded its policy as an earnest of future accomplishments in cosmonautics. (p. 71)

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Today, more than three decades since these lines were written, it can be said with confidence that the works of the outstanding scientist were placed in reliable hands. The Communist Party and the Soviet Government created the necessary economic, social, scientific and technical conditions for the development of cosmonautics, and as a result of this the world's first socialist state opened the road to the stars for mankind. (p. 72)

(5) Record of Soviet space success

During the compartively short period of twenty years, Soviet cosmonautics has traversed the road from the first artificial Earth satellite to the first manned space flight, from one-man spacecraft to big orbital stations with replaceable crews, from the launching of spacecraft purely for research to the largescale and profitable utilization of space technology in the national economy. Flights into outer space may now appear habitual and routine, but this is patent evidence of the tremendous progress achieved by the USSR in the field of space research. (p. 70)

(6) Soviet commitment to space exploration

Cosmonautics has firmly entered the life of the present generation, and more detailed space studies are becoming a major field of human activity. The development of modern science and technology is inconceivable without space research. As was noted in this context in the Report to the 25th CPSU Congress by the General Secretary of the CPSU Central Committee Leonid Brezhnev "global problems such as primary materials and energy, the eradication of the most dangerous and widespread diseases, environmental protection, space exploration and the utilization of the resources of the World Ocean are already sufficiently important and urgent. In the future they will exercise an increasingly perceptible influence on the life of each nation and on the entire system of international relations. The Soviet Union, like other socialist countries, cannot hold aloof from the solution of these problems which affect the interests of all mankind". (p. 70)

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All these fields of research have already grown beyond the stage of initial, groping experiments and are characterized by a systematic and planned study of outer space, the Earth and terrestrial objects in space conditions. In the future each of these fields of study will develop even more rapidly and the scale of investigation will expand. Of course, it is difficult at present to say with confidence what discoveries or fields of space research are the most important ones. It is hardly justifiable to accent, for instance, only on applied research or to restrict to a minimum studies of "near" and "distant" space and technological experiment in favour of other fields of space research. (p. 73)

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The turn towards space studies related to the environment and the Earth's natural resources, that has become evident in the recent past, is not only of scientific and economic importance: it is important for mankind as a whole. The development of cosmonautics is increasingly involving problems of cardinal importance for the entire human community and not just for individual countries.

Likewise, the solution of scientific, technological and economic problems as well as of socio-political problems which are of a global, international importance is being increasingly linked with cosmonautics. When thinking about the future, we also increasingly realize that in the future human activity will depend in many ways on the manner in which space technology is utilized—for peace or for war. (p. 75)

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The 25th Congress of the CPSU outlined the elaboration and implementation of a whole set of effective measures to protect the environment, to use rationally and reproduce natural resources, in particular, "to study natural resources and monitor the state of the environment and the source of its pollution by means of up-to-date scientific and technological facilities". Cosmonautics is designed to play an important role in tackling this task.

Space means make it possible to control the state of the environment from outer space on a global scale. Even more promising is the influence of cosmonautics on preventing an ecological crisis in the coming decades. In addition to the coming transition to wasteless technology, it is intended by means of space vehicles to transfer to outside our planet first the more harmful industries and then the rest, starting with power generation. The development of industry in space will thus make the conditions of man's existence on Earth even more favourable.

Space studies and exploration are exerting a substantial influence on the interaction between nature and society. Owing to the development of cosmonautics, man is making ever more use of the wealth of the planet and the surrounding outer space. Having started with the exploration of the near-terrestrial space, mankind demonstrates its "cosmic potential" As it was written by K. Tsiolkovsky, mankind is showing its ability to influence the evolution of the Universe in the future. (p. 76)

(7) Space exploration as aid to the national economy

Today we are witnesses not only to persistent and comprehensive studies of outer space but also to its large-scale utilization in the interests of the national economy, this being a patent example of the turning of science into a direct productive force. Contemporary cosmonautics is an integrated system of various sciences and theories (theoretical cosmonautics) and, on the other hand, also of numerous experimental and technical and industrial fields (practical cosmonautics) designed to study and utilize space by means of rockets and various space vehicles. (p. 71)

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Cosmonautics is becoming an important branch of the national economy. It is for good reason that the country's latest five-year economic development plans include extensive programmes for activity in space, the application of space technology in the interests of Soviet society. The entire space programme of the Ninth Five-Year Plan was fulfilled. It provided both for the development of fundamental space research and for the utilization of cosmonautics in the interests of the national economy. The "Guidelines for the Development of the National Economy of the USSR for 1976–1980" set the task of carrying on "space research and utilization, to extend research on the application of space means in studying the Earth's natural resources, in meterology, oceanology, navigations, communications and other economic uses". The large-scale development of space research and the effective application of space technology in the national economy are evidence of the great potential of a developed socialist society in science, production and technology. (p. 72)

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The development of cosmonautics and space research opens up fundamentally new ways and possibilities of transforming productive forces and creating the technology of the future. The 25th Congress of the CPSU has called on Soviet scientists to advance these vital fields of scientific, technical and social progress. Thanks to cosmonautics, sweeping horizons are opening up before science, technology and industry, an integrated approach is applied in practice to the solution of scientific and technical problems, to the introduction of their achievements into the national economy, and a substantial contribution is being made to creating the material and technical base of communism.

A characteristic feature of contemporary scientific and technical progress is the transformation of science into a direct productive force and the putting into practice of scientific achievements. Many discoveries and inventions made in the course of space research have now been introduced into non-cosmic spheres of technology and production and are being utilized in agriculture, in the organization and management of the national economy, and in everyday life. (p. 73)

It should be noted that the development of cosmonautics involves several branches of economic activity. This includes the creation of facilities for the output of space technology, the establishment of testing ranges, tracking stations and other land installations required for space flights. It also includes the utilization of space apparatuses for communications, navigation, meteorology and other economic needs. These space vehicles contribute towards the further intensive development of industry and agriculture. Moreover, the results achieved in the process of developing space technology are utilized in purely "terrestrial" industries that are not related to space.

Last but not least, cosmonautics opens the way to create an "extra-terrestrial" industry and technology. A highly automated space industry and "agriculture" are gradually being created on the basis of a thorough study of the specificities and laws of technological processes in space (welding, cutting, processing of materials, etc.), where they take place in physico-chemical and technical conditions differing from those on Earth. Their origination is caused both by the need to develop space technology and further space exploration, and by the need to increase "terrestrial" production by means of unique substance, that are obtained in space and which either cannot be produced on Earth at all or whose production cost is discouraging. (pp. 73–74)

(8) Scientific value of space exploration

It should be borne in mind that the most valuable thing we will be receiving from space in the nearest future is scientific information. True, in the future man will start using space not only as a valuable source of information but also as a store of boundless natural resources, energy, etc. Meanwhile, however, outer space remains primarily an object of cognizance enabling us to obtain important scientific information. The attention that is being given to the problem of information at the present stage in the development of cosmonautics makes it possible to draw the conclusion that the several decades of man's penetration into the expanses beyond the planet can be described as the "information" period of space exploration.

In fact, space exploration is yielding a wealth of information. Within just a few days a single artificial earth satellite can produce information quantitatively comparable with that contained in the world's largest libraries. This poses the very important problem of increasing the efficiency with which this information is processed with the help of terrestrial and space techniques. (pp. 74–75)

(9) Importance of space cooperation; détente as prerequisite

Under present-day conditions, the most effective exploration of outer space and utilization of the achievements of cosmonautics are possible only through an extensive development of international cooperation and concerted effort by all the countries of the world. As is known, space exploration requires considerable allocations. Quite often many costly space projects are beyond the means of individual states and demand the cooperation of a number of countries. Since the flight trajectories of space vehicles pass over the territory of various countries, the need arises for such flights to be regulated by international law. All this determines the international character of space activities.

The view has already been expressed in Soviet literature that in the near future major space projects will be carried out within the frame-work of the international division of labour. Any interested country could take part in the fulfillment of such projects and on the same equal footing share the results obtained with other countries. (pp. 76–77)

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Whereas at the first stage international cooperation in space studies was limited mostly to exchanges and joint discussions of the results obtained, a comparison of methods and, at best, to a coordination of a number of projects, this has also given way to multilateral cooperation in extra-terrestrial observations connected with space experiments. Now it is becoming important to create space vehicles through the joint efforts of various states and use them for peaceful scientific and practical purposes. The results of space research should belong to all the peoples of the world.

But cosmonautics can be used for the good of all nations only when we have a further lessening of tension in international relations, an improvement in the world political climate. From the beginning of the space age, the Soviet Union has called for extensive international cooperation in space studies and striven to place its space achievements at the service of all peoples, in the name of peace and progress. As is stressed in the materials of the 25th Congress of the CPSU, the USSR is successfully continuing its space effort "in the interests of national and world science, in the name of progress for mankind". Soviet accomplishments in the field of space research are recognized throughout the world and have become an asset of world science. (p. 77)

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The development of space projects in the coming decades—the creation, for instance, of permanent orbital scientific stations, scientific bases and industrial facilities on the Moon, and flights to other planets of the solar system—will necessitate vigorous international cooperation. It is quite understandable that the extensive use of space means for studies of the Earth is possible only as a result of purposeful and long-term international cooperation. The Earth is not only a natural "spaceship" in which mankind is "travelling" through the Universe, but it is first of all our home and one which we are not planning to leave in the foreseeable future. It will be possible to keep our home clean and preserve it for posterity only by concerted joint efforts of all the peoples and countries of the planet. (p. 77)

(10) An appeal to reason based on performance

The tone of the Sevastyanov-Ursul article is not offensively polemical, though it takes care to place the Soviet space effort in the best light. Compared with other political writings, particularly on the Soviet charge that the United States seeks to militarize space, as examined in the next section, criticism of the United States and the West is benign. What is significant is the glow of rationality that seems to permeate this piece. It is intended to persuade, not to browbeat; to influence, not to alienate; it is a piece that fits the descriptive term "friendly persuasion."

Drawing upon both truth and fiction, the authors affirm the wisdom of the party as the primary source of Soviet success in space. They summarize the formidable Soviet record in space as a fact well known. They restate with authority the Soviet commitment to continue space exploration. They justify this activity by emphasizing the practical spinoffs from space that aid the national economy. And they underscore the value of space exploration as a means for acquiring scientific information. Persuasive themes.

Finally, the article concludes with a statement on the value of space cooperation and the need for an easing of international tension as a prerequisite.

In brief, the piece appeals to reason on the basis of successful Soviet performance in space. It connotes credibility, and when correlated with the idea of detente as an argument to insure not only peace and progress on Earth and in space but also to insure that all people will benefit from space exploration, it generates a positive appeal. The Soviet Union is made to appear as the prime mover, the center of positive attraction due to its space activities. In a larger context a reader could infer from the article that the

Soviet Union and its socialist system are winners, a country and a system with a future, and thus deserving of emulation and support in world affairs.

U.S. MILITARIZATION OF SPACE: RENEWED EMPHASIS, 1977-78

Renewed focus on "hunter-killer satellite"

Not so benign was the Soviet accusation that the United States was seeking to militarize space. This propaganda theme, for years a stock weapon in the Soviet political arsenal, was revived with renewed vigor during 1977-78. The cause of the revival was the sharp U.S. reaction to Soviet experimentation with military space interceptors—the so-called "inspector-destructor," ASAT (antisatellite), or the "hunter-killer" satellite. U.S. efforts to counteract this military space weapon by developing its own interceptors to match the emerging Soviet capability elicited Soviet claims of innocence and provoked retaliatory Soviet accusations that the United States was seeking to militarize space.[20]

Soviet experimentation with "hunter-killer satellites"

Both space powers have developed what the Americans term "nonaggressive" military space programs—such military applications of space as reconnaisance, navigational and meteorological satellites.[21] But for some time "aggressive" military programs were not pursued with any sense of high priority. The Soviets had come close to developing an "aggressive" system with their fractional orbital bombardment system (FOBS). Failure to continue flight-testing FOBS since 1971 has apparently eased much of the American concern that existed. The United States has regarded a FOBS program neither necessary nor desirable.

Indeed, the disadvantages of space weapons sufficiently outweighed the advantages for both space powers that they denied themselves access to them. Accordingly, in 1967 they agreed not to orbit nuclear weapons or other weapons of mass destruction, and in the SALT I agreement in 1972 they pledged not to interfere with the "national technical means" (that is, reconnaisance satellites) for policing the agreement.[22]

Thus far both sides have adhered to these restrictive agreements. However, evidence during 1976-78 that the Soviets were flight-testing an antisatellite system aroused new concerns about Soviet intentions in space. The Soviets had conducted seven tests of "hunter-killer satellites" from 1967-71. Though conclusive assessments could not be made of these early tests in the absence of satisfactory Soviet data, still the suspicion lingered on that the Russians had developed an inspect-and-destroy capability. (The United States had developed an interceptor system called Saint but abandoned it before its first flight test.)[23]

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[20] Sheldon, United States and Soviet Progress in Space, pp. 44-48.

[21] Ibid., p. 41. According to Sheldon, about 56 percent of U.S. spaceflights are conducted for the Department of Defense, with 48 percent for strictly military purposes. About 69 percent of Soviet flights are for military purposes.

[22] Ibid., pp. 43 and 47.

[23] O'Toole, Thomas. U.S. Draws Up Plans for War in Space. The Washington Post, Jan. 10, 1977, p. A1.

Early suspicions of this emerging new Soviet capability were confirmed by a series of Soviet test flights of "hunter-killer satellites" during 1976–78. In 1976, the Russians used three target satellites and four interceptors; they repeated the same configuration in 1977. The last interceptor to be flown prior to 1980 was the single test in May 1978.[24]

U.S. response to the Soviet "hunter-killer satellite"

(1) The U.S. reaction

U.S. officials and the press expressed alarm at these new developments in Soviet space weapons. Concern was focused not only on the "hunter-killer satellite" but also perceived Soviet progress in the potential use of directed energy weapons in space.

Indicative of the U.S. concern was the final report of February 1977 by Malcolm R. Currie as director of military research in the Department of Defense in the departing Ford administration. Currie expressed concern with "Soviet activities in the area of directed-energy weapons." "We know few details of the Soviet programs," he said, "but the scope and degree of commitment of their interests in these weapons of the future is quite large as judged by their investments in physical plant for research and development." After noting increased Soviet research on concentrated beams of light known as high-energy lasers between 1971 and 1975, Currie said, "There are indicators which point to Soviet interests in particle beams technology which may have advanced weapon applications." He asserted that the Soviet Union "is seizing a new initiative and creating the prospect of a new dimension of military conflicts—war in space." And he warned that "if the Soviet Union chooses to continue along the path they appear to be taking, they will find it a dangerous one." "Perhaps the most portentous Soviet activity in space," Currie said, was the resumption of efforts to develop "hunter-killer satellites."[25]

Throughout 1977 and into 1978 U.S. officials, including President Carter and Defense Secretary Harold Brown, became increasingly worried by the development of Soviet space weapons. This worry was aggravated by the accidental disintegration of a Soviet military satellite (Kosmos 954) over Canada, though Kosmos 954 was a naval reconnaissance satellite and not a "killer satellite." According to the press, American national security specialists were "extremely worried" about the threat posed by Russia's new "hunter-killer satellites." Maj. Gen. George J. Keegan Jr., former Chief of U.S. Air Force intelligence, characterized the threat as "grim."[26] Congressional sources described the developing Soviet military space program as having "immense strategic importance." One Senator exclaimed, "The arms race is entering space and is just beginning to escalate. If steps are not taken immediately to control this lethal contest it could be too late." [27] Such official concerns were reflected in editorial comment in the press.[28]

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[24] Sheldon, United States and Soviet Progress in Space, p. 47.

[25] Wilson, George C. Pentagon Report Envisions Need for Far-Out Weapons. The Washington Post, Feb. 5, 1977, p. A2.

[26] Lyons, Richard D. U.S. Officials Fear Soviet Leads in Hunter-Killer and Spy Satellites. The New York Times, Jan. 30, 1978, p. 1.

(2) Why the sharp U.S. reaction?

Explanations for the sharp U.S. reaction to Soviet progress in military space systems centered on two points: the impact on the strategic balance, and the disastrous effect on U.S. national security should its defensive satellite systems be destroyed.

Currie explained the threat in terms of the balance of power, presumably, having in mind its impact on diplomacy as well as national security. He stressed that the Soviet Union "is seizing a new initiative and creating the prospects of a new dimension of military conflict—war in space." Then he stated categorically:

> We cannot let them obtain a military advantage in space through anti-satellite weapons, because the consequences to the future military balance between the U.S. and U.S.S.R. could be no less than catastrophic.[29]

What antisatellite weapons could do to U.S. defense systems in space (for example, communications, navigation and reconnaisance satellites) was best summed up by one intelligence source who said, "They're up there like sitting ducks," meaning "ducks" in a shooting gallery waiting indefensively to be shot down.[30] U.S. defense officials expressed fears that a successful antisatellite system could prevent them from communicating with and thus giving orders to ships, planes, submarines, missile silos and ground forces around the world. Such a destructive capability could give the Soviets a critical strategic advantage if nuclear war broke out. With its space communications silenced, it was argued, the United States could be prevented from ordering a retaliatory strike in the event the Nation were attacked.[31]

In brief, the "hunter-killer satellite" exposed the vital center of U.S. national security, its first line of detectors and communications. Hence, the vigor of the U.S. reaction.

(3) Counteraction through diplomacy and defense

Faced with this threat to its security, the United States sought to create a counterforce capability against Soviet space weapons; it also sought to do this without triggering an arms race in space through diplomacy.

Early in March 1977, President Carter reported in a press conference that he had suggested to the Soviets that "we forgo the opportunity to arm satellite bodies and also to forgo the opportunity to destroy observation satellites." [32] But the Russians ignored his appeal and continued testing "hunter-killer satellites" throughout the rest of the year.

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[27] Lyons, Richard D. Carter Favors Ban on Atomic Reactors in Earth Satellites. The New York Times, Jan. 31, 1978, p. 1.

[28] See, No Time to Hunt in Space. (Editorial.) The New York Times, Oct. 14, 1977, p. A26, and, 20 Years in Space. (Editorial.) The Christian Science Monitor, Oct. 13, 1977, p. 30.

[29] Wilson, George C. Carter Concerned on Outer-Space War. The Washington Post, March 10, 1977, p. A4.

[30] The Washington Post, Jan. 10, 1977, p. A1.

[31] The New York Times, Jan. 30, 1978, p. A1. For other discussions of this problem, see, Zorza, Victor. Soviet-Killer-Satellite Jogs Pentagon. The Christian Science Monitor, May 11, 1977, p. 7, and Middleton, Drew. Soviet Tests Producing Increase in U.S. Space Defense Research. The New York Times, Feb. 15, 1977, p. 8.

[32] The Washington Post, Mar. 10, 1977, p. A4.

In testimony before the House Foreign Affairs Subcommittee on Europe and the Middle East in the fall of 1977, Marshall Shulman, presidential adviser on Soviet affairs in the State Department, urged that an agreement be reached with the Soviets before the techniques of these space weapons could be perfected. But faced with continuing Soviet experimentation, he said, the United States "would clearly draw on its strong technological base to develop capabilities at least as strong as those of the Soviet Union." [33]

As a hedge against failure of the diplomatic option which seemed to have only very limited possibilities of success even though discussions had been agreed upon, the United States expanded its military space programs. In March 1977, Robert N. Parker, Acting Director of Research and Development in the Defense Department, disclosed that U.S. military space programs were being accelerated. He noted that $2.77 billion was earmarked for fiscal year 1978, $478.5 million more than Congress had appropriated in 1976.[34] In September, the Air Force awarded a contract to the Vought Corp. in Dallas to develop an instrumented target for antisatellite tests, perhaps as early as 1981.[35] Large contracts were also awarded to Hughes Aircraft, Lockheed, TRW, and LTV to develop an ASAT system.[36]

In brief, the United States, responding to the Soviet military threat in space, as one press account put it, "mounted a research and development effort aimed at matching and even overtaking the Soviet lead in hunter-killers and ocean-scanning satellites." [37]

In June 1978, after the successful completion of a Russian test on May 19, talks began in Helsinki on banning "hunter-killer satellites," but were inconclusive. Two separate rounds of talks took place in early 1979 in Switzerland and during April–July in Vienna. But they too were inconclusive. The Soviets demanded that the United States halt its development of the Space Shuttle as part of an agreement to prohibit antisatellite weapons. (In February 1981, the Soviets charged that the first task of the Space Shuttle then in its final testing mode was "to test a target finder for a laser weapon which will be put into orbit and is designed to destroy Soviet missiles." [38] Subsequent success of the Space Shuttle was greeted by an outpouring of Soviet propaganda statements charging that its primary purposes were military.) The United States reportedly hoped to reach agreement on a 1-year ban on testing ASAT's with the expectation that it would be a prelude to a treaty banning weapons entirely.[39]

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[33] O'Toole, Thomas. Space Wars: Laser-Armed Killer Satellites, False Signals Worry Pentagon. The Washington Post, Nov. 6, 1977, p. A1.

The disintegration of Kosmos 954, a nuclear-driven navigation satellite, over Canada in early 1978 aroused renewed concerns about the potentialities of killer-satellites to threaten American communication systems. But it also spurred diplomatic efforts by President Carter to urge upon the Russians a ban on Earth satellites from carrying radioactive materials as a protection against contamination in event of an accident. The President also gave assurances that at the moment the Soviets could not threaten American communication systems. (The New York Times, Jan. 31, 1978, p. 1.)

[34] The Washington Post, Mar. 10, 1977, p. A4.

[35] The New York Times, Jan. 30, 1981, p. A4. This date has now slipped to 1984 or 1985.

[36] The Washington Post, Nov. 6, 1977, C4.

[37] The New York Times, Jan. 30, 1978, p. A4.

[38] Moscow Tass International Service in Russian, 12203 GMT, Feb. 15, 1981, FBIS 20.

[39] Facts-on-File, Dec. 31, 1979, p. 979D2.

Soviet propaganda attacks on United States

Counterattack was the natural Soviet response to publicly expressed American concerns about the Soviet development of space weapons. In defense of its developing ASAT system the Soviets took the offensive, accusing the United States of militarizing space—an old propaganda canard dating back early in the Space Age—and in an air of offended innocence portraying the Soviet Union as the victim not the perpetrator.

Illustrative of Soviet political distortion of legitimate U.S. efforts to counter Soviet space weapons is the commentary by V. Begishev published in the February 1, 1977 issue of Leningrad Pravda. The focus of the attack was two articles on the "Soviet threat" in space, one published in Newsweek of December 6, 1976 and the other in The Washington Post of January 10, 1977. Begishev referred to the "fable" of Soviet lasers blinding U.S. satellites noted in Newsweek and to the Pentagon's "alarm" over the potentialities of "hunter-killer satellites" as demonstrated by Soviet testing, "though how these tests were detected no one knows." In Begishev's view both articles, "besides the obvious intention to sow mutual misgivings in both sides," suggested two further themes:

> First is the growing pressure from the military-industrial complex, which is striving to transfer the arms race into new spheres. The U.S. aerospace industry is now concluding military contracts worth about $15 billion per annum, and appropriations channeled into development of space equipment "for defense purposes" exceed $2 billion. The people who have such sums at their disposal to a certain extent are becoming an independent force capable of seriously hampering the peace-loving policy which, judging by its statements, the new Carter Administration has been intending to implement. It has been not Soviet but U.S. military figures who so far have discussed the prospects of utilizing shuttle spacecraft to seize and carry off others' space stations and satellites, or the creation of "strike" spacecraft. At the same time it is clear that pollution of the "fourth medium" by weapons would have adverse consequences of an unpredictable nature for the cause of detente.
>
> And second: Such speculation shows an obvious desire to reassure the public with the notion of the possibility of a war that is "not terrible" and of battles that would take place at altitudes beyond all imagination and would end "without a single shot fired on earth." Newsweek, expounding this idea itself, calls it "almost certainly a utopia." But the word "almost" is superfluous here. It is precisely a utopia, and a harmful one at that. Relations between the great powers can develop either—and the Soviet Union sincerely desire this—in the direction of total and stable peace or toward war, which would be the end of civilization. Seen in a historical perspective, there is no third direction. The theory of "limited conflicts" whether in space or on earth was thought up by those who, using the theory to hide behind, would like to create a total confrontation.

In contrast to this negative American view of space is that of the Soviets which Begishev described in this positive light:

> Granted, Soviet leaders also speak of "conquering space," but in a quite different sense. "By expanding our activity in the study of space," L. I. Brezhnev, General Secretary of the CPSU Central Committee, noted in one of his speeches, "we are not only laying the foundations for future gigantic conquests by mankind, whose fruits will be enjoyed by future generations, but we are also drawing immediate practical benefit today for the earth's population, for our peoples, and for our cause of Communist building."
>
> In this space offensive the USSR is cooperating not only with socialist, but also with many capitalist countries.

Placing the burden of responsibility on the United States for the militarization of space, Begishev concluded: "Why do those who love to fantasize on space themes not dream of the boundless horizons of such cooperation, instead of considering methods of 'hunting' other people's spacecraft?" [40]

In a Tass report on April 4, 1977 the Soviets (erroneously, it should be noted) accused the United States of violating space agreements on the exploration of outer space for peaceful purposes. According to Tass, the Los Angeles Times had published a story about a Pentagon report to Congress on a secret program to develop an ASAT system. Tass concluded:

> The special atmosphere of secrecy surrounding this Pentagon program is no accident, for it is being implemented in direct violation of the treaty on the principles of activities of states in exploring and utilizing outer space, including the moon and other celestial bodies, a treaty signed by the United States.
>
> The Pentagon report bluntly states that it regards satellites as a means for supporting military operations. The compilers of the report apparently realize that their plans are illegal: it is not for nothing that this cynical document notes that, though today outer space is regarded as untouchable, this situation may eventually change.[41]

The message is clear: The United States is a sinister force in the exploration of space.

In similar fashion G. S. Khozin cast the United States as "the heavy" in his article on a new space agreement appearing in the leading Soviet journal on American affairs, USA: Economics, Politics, Ideology. Success in cooperation in space and in other fields of science and technology, he said, depended upon the United States taking on a realistic approach to arms control, including "the prevention of the use of outer space for military purposes." Again placing the burden of responsibility on the United States, Khozin wrote:

> Everyone knows of the attempts made by the heads of the U.S. Department of Defense to expand their plans for the military use of space. For this purpose, they are resorting to any kind of trick and are trying to misinterpret the problems arising during the course of arms limitation talks.

By way of underscoring this point Khozin recalled the Newsweek commentary "about the fourth—cosmic—dimension of war" and the Los Angeles Times account of the "Pentagon's intention to develop 'antisatellites,' that is, space systems for the destruction of the satellites of other states."

Khozin contrasted such U.S. military applications of space with the altruistic Soviet approach. He wrote in conclusion:

> The space age was begun 20 years ago by the Soviet Union. The TASS report on the launching of the first artificial earth satellite in the world said: "Our contemporaries have had the privilege of witnessing the way in which the free and conscious labor of the people of the new, socialist society can make the wildest dreams of mankind a reality." During this year of the 60th anniversary of October, our nation will continue to aim all of its achievements at the good of the workers and establish the ideals of genuine freedom, equality, justice and social progress.[42]

Thus the United States was portrayed as the violator of peace in outer space, the Soviets as the enforcer of peace. This did not square with reality since both were developing military space systems, the Soviets at a faster pace than the Americans, notably the

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[40] Begishev, V. Escalation of Morbid Fantasies. Leningrad Pravda, Feb. 1, 1977, p. 3, in FBIS 52.

[41] Moscow Tass in English, 1644 GMT, Apr. 4, 1977, in FBIS 58.

[42] Khozin, G. S. New Space Exploration Agreement. USA: Economics, Politics, Ideology, No. 8, September 1977, translated in JPRS 69794, Sept. 15, 1977, pp. 65–66.

"hunter-killer satellites." In April 1980, after a 2-year lapse, the Soviets tested another "hunter-killer satellite," Kosmos 1174. It was not clear whether it was a success or failure; one Pentagon source termed it an "apparent failure" in part because the "hunter-killer satellite" might not have approached close enough to the target to destroy it. Before this test the Soviets had conducted 16 tests where their antisatellite demonstrated the capability to intercept a target satellite. Pentagon officials speculated that this test possibly signaled a more assertive phase in Soviet arms policy. The American antisatellite system is still in the development stage but unlikely to be tested before 1982.[43]

THE "SPACE RACE," A FADING THEME

The so-called "space race" was once a dominant theme in Soviet-American space relations. By the late 1970's, however, this theme seemed to have faded away. Placing Soviet and American space activities within a comparative context, particularly when looking at space historically, has continued to be a convenient method of analysis on the American side.[44] But an examination of various news commentaries during the period September 1977 through the summer of 1978 suggests little of the intense competitive spirit that marked the early years of space. For example, the report in The Christian Science Monitor when Salyut 6 was about to break Skylab's 84-day endurance record for manned flight on March 4, 1978 was restrained and matter-of-fact. "Once the record is broken," wrote Kenneth Gatland from London, "the U.S. has little chance of regaining it for many years because there is no ongoing space station program."[45] NASA officials routinely stated in testimony before congressional committees the U.S. policy of "maintaining a position of leadership in space science and planetary exploration," as NASA Administrator Robert A. Frosch had done in 1979.[46] And others stressed the importance of a competitive response to the busy Soviet space program. But, by and large the notion of a space race was far from being a concern of the American people who were scolded editorially by The Christian Science Monitor in January 1978, on the occasion of continued Soviet space successes, for a "lackadaisical public attitude" toward space.[47]

Much the same can be said for the Soviet side. While the Soviets have not hesitated to emphasize their "firsts" in space, nonetheless, they have in general taken a more mature approach and sophisticated attitude toward their many achievements in space. Having "arrived" as a major space power, the Soviets seemed to comport themselves with an air of confidence touched with a certain appealing dignity. They did not flaunt the success of Salyut 6 in outdoing Skylab, for example, but rather seemed to take this achievement as a matter of course given the planning and pace of their space programs. Congratulations extended to Romanenko and Grechko, the orbiting cosmonauts, by the American Skylab team was covered in the Soviet media.

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[43] O'Toole, Thomas. Russians Resume Testing of Satellite Designed to Hunt and Destroy Others. The Washington Post, April 19, 1980, p. A6, and Burt, Richard. Russians Again Test a "Killer Satellite." The New York Times, April 19, 1980, p. 28. This date has now slipped to 1983.

[44] See, for example, Sheldon, United States and Soviet Progress in Space, p. 29.

[45] Gatland, Kenneth. Soviets Gaining Lead in Long Spaceflights. The Christian Science Monitor, Feb. 28, 1978, p. 1.

[46] U.S. Congress. House Committee on Science and Technology. 1980 NASA Authorization. Hearings, 96th Cong., 1st sess. Washington, U.S. Government Printing Office, 1979, vol. 1, pt. 2, p. 532.

[47] The Christian Science Monitor, Jan. 17, 1978, p. 24.

An explanation for the decline of the "space race" could be attributed to declining U.S. interest in manned space flight after shutting down the successful and globally eye-catching Apollo program. The competitive spirit, however, could rise again with the successful flight of the Space Shuttle. A continuing downturn in political relations could contribute to sharpening this competitive spirit.

ROMANENKO-GRECHKO SPACEFLIGHT: A CASE STUDY OF SPACE POLITICS

LINKAGE OF SPACE AND POLITICS

Three anniversaries in autumn 1977

The Romanenko-Grechko spaceflight from liftoff of Soyuz 26 on December 10, 1977 to landing on March 16, 1978 provides an illuminating case study of Soviet space politics. The prelude to the flight is particularly instructive in demonstrating Soviet linkage between space and politics.

For the Soviets, the autumn of 1977 had special political meaning. Anniversaries of major events in Soviet history were being commemorated. These events provided a unique opportunity to link Soviet success in space to the power of the Soviet state that had been responsible for this success. The conclusion to be drawn was self-evident.

By coincidence the 60th anniversary of the Bolshevik Revolution and the 20th anniversary of Sputnik I's launching fell conveniently only weeks apart. It was understandable, therefore, that the Soviets would link both events in a cause and effect relationship.[48] Accordingly, Sevastyanov and Ursul began a feature article entitled, "Cosmonautics and Social Development,"

> This year all of progressive mankind is celebrating the 60th Anniversary of the Great October Socialist Revolution, but 1977 is also the 20th anniversary of the launching by the Soviet Union of the first artificial satellite of the Earth and the commencement of the "space era."

And they continued,

> The accomplishments of Soviet cosmonautics have won international acknowledgement and convincingly demonstrate the potential created by the socialist system in scientific and technical progress.[49]

The authors went on to reiterate familiar Soviet themes in space politics, the main thrust of which was to eulogize the Soviet system using success in space as self-confirming evidence of its virtue and value.

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[48] For American commentaries on the anniversary of Sputnik and statements on the wider appreciation of space exploration, see, the editorials in the Washington Post, Oct. 7, 1977, p. A20 and The Christian Science Monitor, Oct. 13, 1977, p. 30.

[49] Sevastyanov and Ursul, Cosmonautics and Social Development, p. 70.

Shatalov in Philippines

Lt. Gen. Vladimir Shatalov, a cosmonaut and deputy of the U.S.S.R. Supreme Soviet, symbolized political linkage between the two anniversaries when he, as a universally recognized space hero, headed the Soviet delegation to the Philippine Islands to commemorate the 60th anniversary of the Bolshevik Revolution. (Recall also the Tereshkova visit to England noted above.) The visit provided suitable occasions for mutual expressions of friendship between Shatalov and President Ferdinand Marcos and his wife, Imelda, and for emphasis by Shatalov on the practical benefits of space exploration for countries like the Philippines.[50]

The political purposes behind the Shatalov visit were clear: President Marcos had agreed to establish diplomatic relations with the Soviet Union during a visit to Moscow in 1976; U.S.-Philippine relations were being severely strained over negotiations on the critical issue of continued U.S. bases; the Soviets were seeking to exploit these differences and expand their political influence in that part of Southeast Asia.

Credibility of Soviet space claims

What gave strength and appeal to this example of linkage was the credibility of Soviet claims that had been demonstrated by performance. They had indeed made remarkable progress in space exploration and seemed determined to pursue their program which held the promise of success in the future. As one Western source said at the time,

> Look, these guys are in space for good. They've had problems, but so have we. And eventually, they may solve their technical difficulties and be able to fulfill all the promises they make and the hopes they have. I admire them for that.[51]

Another observer compared the U.S. and Soviet space programs, favorably to the Soviets. In the post-Apollo period the U.S. program had been marked by shifts and changes of direction and would only begin to revive with the first few flight tests of a Space Shuttle in 1981. In contrast, the Soviet program "has continued doggedly onward." [52]

THE LAUNCHING OF SALYUT 6

More than just verbalizing on the connection between space, politics, and anniversaries, or relying upon past space successes, the Soviets undertook new, more innovative, and more dramatic spaceflights that were to provide both the occasions and the material for space politics. Such was the case with the launching of Salyut 6, an orbiting space station that for the next 3 years was to receive a veritable parade of crews from Soyuz 26 through Soyuz 37.

Salyut 6 was launched on September 29, 1977. As customary the Soviet announcements gave no details beyond the general comment that the purpose of this orbital station was to conduct scientific and technical research and experiments, and to check out the design of onboard systems and equipment. Western space specialists speculated that the new station could be a prelude to a manned mission to coincide with the anniversaries of Sputnik I and the Bolshevik Revolution, and that a crew of cosmonauts, including one from Eastern Europe, might soon be dispatched in a small Soyuz spacecraft to link up with Salyut 6.[53]

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[50] A Cosmonaut Looks at the Philippines. New Times, No. 1, Jan. 1978: 23–24.
[51] Klose, Kevin. 20 Years After Sputnik. The Washington Post, Oct. 4, 1977, p. A15.
[52] Ibid.

Described as the "centerpiece of the Soviet manned space effort in this decade," the Salyuts had undergone steady improvement in instrumentation, control and navigation systems since the first flight in 1971. The primary purpose of Salyut 3 and 5 were military reconnaissance, and of Salyut 1 and 4, civilian science. The mission of Salyut 6 was unclear: its low orbit (permitting high-resolution photography) suggested a military purpose, but its maneuverability into higher orbit could have ruled this out.[54]

DOCKING FAILURE OF SOYUZ 25

Political relevance of flight

What seemed politically intended to highlight the 60th anniversary of the Bolshevik Revolution and the proclamation of the much-publicized new Soviet constitution (popularly called the "Brezhnev constitution") was the linkage of these events with the docking of Soyuz 25 with Salyut 6. But this space effort ended in failure when serious problems developed in the docking procedures and the flight had to be aborted. On the eve of liftoff it was speculated that the Russians would attempt to surpass the U.S. endurance record of 84 days, 1 hour, 15 minutes set by Skylab 3.[55]

With a copy of the "Brezhnev constitution" in hand and a vocal declaration that "We're opening the third decade in space," Lt. Col. Vladimir Kovalenok, commander of Soyuz 25, and flight engineer Valeriy Ryumin entered their spacecraft and lifted off from Baikonur cosmodrome at 0540, October 9, 1977. The constitution, the object of the most intense Soviet propaganda campaign seen in many years, had been "endorsed" by the Supreme Soviet a few days before after 4 months of "nationwide discussion." The declared purpose of the spaceflight was stated officially, and succinctly, to carry out "joint experiments" from the scientific station, Salyut 6.[56]

Failure and disappointment

But the cosmonauts failed to link up with Salyut 6. Without official explanation beyond the cryptic comment of "some deviation from a planned docking regime," the operation was aborted and the spacemen softlanded near Baikonur after a flight of only 49 hours and 46 minutes.[57]

David K. Willis, Moscow correspondent of The Christian Science Monitor, probably best summed up initial Soviet political intentions and at the same time their grave disappointment at the unexpected conclusion when he wrote:

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[53] Wilford, John Noble. Salyut 6 Station Put into Orbit by Soviet. The New York Times, Sept. 30, 1977, p. A20.

[54] Ibid.

[55] Fisher, Dan. Soviets Send 2 Men on Orbital Mission. The Washington Post, Oct. 10, 1977, p. A16.

[56] Ibid., and Moscow Tass in English, 0833 GMT, Oct. 12, 1977, in FBIS Daily Report: Soviet Union, vol. 3, Oct. 12, 1977, p. U1.

[57] The New York Times, Oct. 12, 1977, p. A9.

> The sudden failure of the latest Soviet space venture is a double disappointment for the Kremlin. It is a blow for Soviet prestige—and it raises new questions about a vital part of the Soviet manned space program itself.
>
> The launching of Soyuz 25 seemed clearly intended to dramatize Soviet skills and standing as the nation was celebrating the 60th anniversary of the 1917 Revolution, the beginning of the third decade of the space age begun by the Soviet Sputnik October 4, 1957, and the new state Constitution.
>
> Soviet newspapers linked all three themes to the launching in their morning editions of October 10. Then came the dramatic news of the docking failure with the space station Salyut 6. It can only have been a deep disappointment to Soviet officials, it is thought here.
>
> The Kremlin was believed to have planned an attempt on the U.S. space endurance record of 84 days and a new walk in space to mark the November 7 anniversary of the 1917 Revolution.[58]

The Soyuz 25 flight marked the third failure in a little more than 3 years of attempts to dock a spacecraft with an orbiting Salyut. Prolonged flights and extensive experimentation in space, a long-term plan and central element in the Soviet space program, could not proceed until this maneuver was perfected. Hence, with this failure ambitious Soviet plans for men living and working in space received a severe setback.[59]

American space officials speculated that the Soviet cosmonauts had overshot the orbiting Salyut 6 and were unable to make a second attempt at docking because they lacked battery power.[60] Soviet officialdom showed its disappointment and displeasure with the performance of its cosmonauts by denying them full honors ordinarily accorded their more successful space colleagues.[61]

SUCCESSFUL DOCKING OF SOYUZ 26

Recovery from series of failures

Failure of Soyuz 25 was more than compensated by the docking of Soyuz 26 with Salyut 6 and the succession of successful dockings by other Soyuz spacecraft that were to follow for more than a year. Almost 2 months to the day after the failure of Soyuz 25, Soyuz 26, commanded by Lt. Col. Yuriy Romanenko and assisted by flight engineer Georgiy Grechko, lifted off from Baikonur cosmodrome at 0419 December 10 on what was to be a space voyage of great achievements. David K. Shipler, correspondent of The New York Times, reported from Moscow.

> Amid public affirmation of the crew's "excellent preparation" and its own determination "to apply all efforts to fulfill the tasks before us," as the spaceship's commander put it, the flight clearly carried Soviet hopes for a recovery from a series of failures in the manned program.[62]

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[58] Willis, David K. Space Docking Problems Dog Soviets. The Christian Science Monitor, Oct. 11, 1977, p. 1.

[59] Ibid., and Moscow Domestic Service in Russian, 1405 GMT, Oct. 11, 1977, in FBIS 82.

[60] O'Toole, Thomas. U.S. Specialists Believe Soyuz Computer Failed in Attempt at Docking. The Washington Post, Oct. 12, 1977, p. A21.

[61] Belated Awards for the Crew of Soyuz 25. RFE/RL. Radio Liberty Research, RL 25/78, Jan. 30, 1978, 7 pp. "On November 15—i.e., more than a month after their return to Earth," the Radio Liberty report said, "both Kovalenok and Ryumin were awarded the Order of Lenin. And nothing more. Up to now all cosmonauts had had the title Hero of the Soviet Union conferred upon them after their first space flight, as well as being awarded the Order of Lenin and the Gold Star medal."

[62] Shipler, David K. 2 Soviet Astronauts Heading for Link-Up With Space Station. The New York Times, Dec. 11, 1977, p. 23.

According to Tass, the flight program of Soyuz 26 "envisages experiments jointly" with Salyut 6.[63] The first step came about quickly, and successfully. At 0602 Moscow time on December 11, Soyuz 26 docked with Salyut 6 and began what was to be a record-breaking program which Tass said,

> includes the study of physical processes and phenomena in space, the study of the earth's surface and its atmosphere to obtain information in the interests of the national economy, technological experiments, medical and biological research, and technical experiments and testing of the station's onboard systems and equipment.[64]

Restraint in political reaction

Judging from a survey of Soviet reports, success in docking, along with the "space walk" to check the docking unit (it needed no repairs), pleased Soviet space authorities. An achievement on this scale spoke for itself; it needed no excessive propaganda to underscore its importance. The space performance was its own political statement.

Accordingly, Soviet reports on this space mission to foreign and domestic audiences for the next month were marked by an absence of obvious propaganda: They were straight-forward, restrained, matter-of-fact, and in some instances, highly technical. They focused on such matters as the condition of the cosmonauts, their activities in the space station, and Soviet future expectations with respect to long-range spaceflight. Shatalov, for example, gave a full accounting of the flight over Moscow Radio on December 20 that suggests the tone and content of media coverage. He concluded:

> And now I am happy to note that the crew carried out all the work connected with the spacewalk efficiently and well. The flight engineer worked well. He carried on a detailed reportage on each component as he examined it. He made a report on each connector, on each millimeter of clearance and on each movement [podvizhnost]. Well, you heard the reportage so there is probably no point in repeating everything that the crew reported on so well. The ship's commander did a great deal of work. He assisted the work of the engineer, passed him all the necessary instruments, the television camera, and provided security during the walk.
>
> The work that has just been done will enable us successfully and boldly to continue to carry out the whole program of further long-term work of the Salyut orbital station.
>
> At the time one could say it was not only the first trial step in leaving and working outside the ship, but was also a practical step directed toward checking out the possibility of saving the crew of an orbital station, which might be necessary in the future, or another spaceship not having a unified docking system in the event the ship's crew were unable to return to earth unaided. At the present time, it must be said that this work has already gone beyond the bounds of experimental work and is now acquiring a purely practical nature. The station fully insures movement and work outside the station and on its surface, the installation of various scientific instruments and equipment, and if necessary the carrying out of all kinds of examinations and regulating work and, if needs be, repair and overhaul work. Therefore, it is essential work, work which most likely will accompany every flight, and all the more so the lengthy flight of a long-term orbital station.[65]

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[63] Moscow Tass International Service in Russian 0650 GMT, Dec. 11 1977, in FBIS Daily Report: Soviet Union, vol. 3, Dec. 12, 1977, p. U1.

[64] Ibid.

[65] Shatalov Interiew. Moscow Domestic Service in Russian, 0830 GMT, Dec. 20, 1977, in FBIS Daily Report: Soviet Union, vol. 3, Dec. 21, 1977, pp. U2–U3.

MULTIPLE LINKUPS WITH SOYUZ 27 AND PROGRESS 1

A new "first" with multiple docking

Operations using Salyut 6 moved along flawlessly during January and February 1978. Another crew and a space vehicle transporting supplies docked with the space station, expanding the activities of the crews aboard, extending the time in space of the Romanenko-Grechko space team to the point of breaking the Soviet record for endurance, and in general providing valuable subject matter for the exercise of space politics.

Soyuz 27 was launched at 1526 January 10, 1978 with Lt. Col. Vladimir Dzhanibekov as commander and flight engineer Oleg Makarov as his companion.[66] At 1706 on the following day, Soyuz 27 linked with Salyut 6 to establish the first multiple docking in space, thus providing, as David K. Willis noted, "another opportunity for Moscow to proclaim the success of its own science and technology." [67]

Praise for the Soviet space feat

Both the Russians and the Americans praised this new space feat. Tass acclaimed the multiple linkup as a "significant new stride in the development of Soviet space flight." Soviet space official Konstantin Feoktistov said that this new capability opened "possibilities for more effective exchange of crews, for getting supplies to scientific expeditions and rapid organization of rescue operations if need be." [68] Former U.S. astronaut Eugene Cernan unfavorably compared the primitive Soyuz to the developing U.S. shuttle vehicle—"The U.S. shuttle is aeons of time ahead of the Soyuz." But he acknowledged, "You have to congratulate them. The fact is, they're there—and we're not." [69]

After 5 days in space Dzhanibekov and Makarov returned to Earth aboard Soyuz 26 sometime before 0330 on January 16. Leaving Romanenko and Grechko aloft in Salyut 6, as Craig Whitney of The New York Times said, "bolstered by fresh supplies, 5 days of company and the prestige of making the first multiple rendezvous in space," they brought new and deserved credit to the Soviet space program. Shatalov explained that with this mission,

> an opportunity has been created for replenishing the supplies of an orbital station, for supplying it with fuel, oxygen, food, photo and film facilities, with the help of transport ships, manned or unmanned . . . we can arrange transportation of apparatus and supplies to the orbiting station and make room for more important sophisticated equipment on board.[70]

Western observers saw in this latest achievement "a major advance" in the Soviet space program. One Western European scientist noted that the Soviet cosmonauts demonstrated the capability to assemble a true space station orbiting the Earth and keep it manned and supplied for long periods of time, a feat the Americans were not expected to accomplish until 1981 with their Space Shuttle.[71]

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[66] Whitney, Craig R. 2 Russians Flying to Meet 2 in Space. The New York Times, Jan. 11, 1978, p. 1.

[67] Whitney, Craig R. 2 Aboard Soyuz Join Comrades in Space Linkup. The New York Times, Jan. 12, 1978, p. A1, and Willis David K. Soviet Space Confidence Growing. The Christian Science Monitor Jan. 11, 1978, p. 26.

[68] The New York Times, Jan. 12, 1978, p. A1.

[69] Benjamin, Milton R. Soviet Space First: Dual Salyut Linkup. The Washington Post, Jan. 12, 1978, p. A20.

[70] Whitney, Craig R. 2 Soviet Astronauts Back on Earth as 2 Other Stay Aboard Salyut. The New York Times, Jan. 17, 1978, p. 14.

Arrival of first space transport

A further step in building a space station was taken on January 20 when the Soviets launched an unmanned space transport called Progress 1.

On January 22, Progress 1 docked with Salyut 6, accomplishing the first unmanned space supply mission. As Tass described the achievement:

> For the first time in the history of cosmonautics a transportation operation was carried out with the use of an automatic spaceship to bring to a manned orbital station fuel for refueling engines, equipment and materials for ensuring the life of the crew and for conducting scientific research and experiments.[72]

On Feburary 6, 1978, Progress 1, having delivered its cargo to the orbiting cosmonauts who unloaded it, was separated from Salyut 6 and allowed to burn up in the atmosphere as it descended.[73]

The value of this space transport operation was quickly acknowledged in Moscow as well as in the West. According to a Western space specialist, the Progress 1 mission demonstrated that the Soviets solved refueling and supply problems that had cut short previous manned flights. One specialist said, "It would give them the green light not only for long individual flights but for a high degree of occupancy of their space stations." [74] Cosmonaut Oleg Makarov exclaimed that,

> 1978 will be a turning point in the Soviet program of explorations in a near-earth orbit. . . . It is quite clear that expeditions should be constantly replenished with fuel and scientific materials, air and water to enable the cosmonauts to work for long periods of time in orbital stations.[75]

Reaction in Soviet media: Restrained

A survey of some Soviet media coverage on their space activities during January and February 1978 suggests the same characteristics as noted above. Space success on the scale that the Soviets were then achieving needed no exaggeration; it spoke for itself. Accordingly, Soviet commentaries were straight-forward, without obvious propaganda overtones, and by and large reflecting an apparent desire to communicate responsibly in detail to the Soviet people and their leadership. Articles by leading Soviet space scientists were summarized and excerpted to be used in a Tass release or over Radio Moscow. Such reports were informative, somewhat technical but served the purpose of communicating the details of what was being done in space. A great effort seemed to be made to explain the many scientific experiments taking place in Salyut 6. Scientists seemed to simplify their commentary for the lay audience but not to the point of "talking down" to them.[76]

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[71] Ibid. The Christian Science Monitor wrote a chiding editorial (Jan. 17, 1978, p. 24) in which they called attention to the "lackadaisical public attitude" in the United States toward space exploration. The Soviet effort, it said "ought to give the United States pause. Is it in danger once again of falling behind the Russians in so important a scientific field?" Some NASA officials were concerned about the "modest plans" for further study of space stations included in the forthcoming budget. According to the Monitor, "now is the time to focus greater efforts on developing" orbiting space stations. "The Soviets are devoting far more of their resources to this effort than are Americans. The present lackadaisical public attitude toward space projects should not lull Congress into believing Americans can rest indefinitely on past achievements."

[72] Klose, Kevin. Soviets Launch Salyut Supply Craft. The Washington Post Jan. 21, 1978, p. A10, and, Moscow Tass in English, 1227 GMT, Jan. 22, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Jan. 23, 1978, p. U3.

[73] Moscow Tass in English, 0942 GMT, Feb. 6, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Feb. 6, 1978, p. U5.

[74] The Washington Post, Jan. 22, 1978, p. A20.

[75] Ibid.

Authoritative articles on space science matters written by space scientists and engineers appeared in the leading press such as Pravda. A case in point was that by candidate of technical sciences Yu. Pavlov and engineer L. Ivanov entitled, "Tanker, Freight Carrier and Tug." This article seemed to demonstrate the care with which Soviet space scientists communicate with the party elite and leadership, and through them, to the Soviet people. Pavlov and Ivanov gave details of the Progress 1 mission in a clear, matter-of-fact way, without propaganda flourishes. The piece gives the impression of being a serious attempt to communicate in a clear, understandable way on an important space operation. It carried the stamp of authority (since it appeared in Pravda), and suggests the idea, deducible from so many Soviet commentaries on space, that the Soviet space program is going forward according to an established, rational plan, that it is serious-minded, and that Soviet scientists knew what they were doing, why they were doing it, and that they felt comfortable in their decisions. In brief, the article, as in the case of many others of this type, seemed to communicate essential facts on an important space mission and gave enlightenment along with, by inference, assurances.[77]

THE DOCKING OF SOYUZ 28 AND ENDING OF ROMANENKO-GRECHKO FLIGHT

Russian and Czech together in space

The Romanenko-Grechko spaceflight ended soon after the docking of Soyuz 28 with the Salyut 6-Soyuz 27 space station. Both events had particular political meaning: Romanenko and Grechko broke the American record for length of time in space; Soyuz 28 marked the first international flight of cosmonauts from the socialist states. A unique opportunity was thus created for applying space to politics.

Soyuz 28 was launched from Baikonur Cosmodrome at 1828 March 2, 1978. Veteran cosmonaut Col. Aleksy A. Gubarev was in command; "cosmonaut researcher" Capt. Vladimir Remek, a pilot in the Czech air force, accompanied him. The mission called for docking with the Salyut 6-Soyuz 27 orbital station and the carrying out of "joint investigations" with Romanenko and Grechko.[78]

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[76] See, for example, the Tass release on the biological experiments being conducted aboard Salyut 6 which was based on an article by Nikolay Dubinin, described as "a noted Soviet geneticist," "and published in Sovetskaya Rossiya, Moscow Tass in English, 1401 GMT, Jan. 29, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Jan. 30, 1978, p. U3.

[77] Moscow, Pravda in Russian, Feb. 8, 1978, p. 3, in FBIS Daily Report: Soviet Union, vol. 3, Feb. 17, 1978, pp. U1–U4.

[78] Whitney, Craig R. Czech is Orbited with Russian for Salyut Rendezvous. The New York Times, Mar. 3, 1978, p. A11. For more detailed information, see Moscow Tass in English, 1721 GMT, Mar. 2, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Mar. 3, 1978, pp. U1–U2.

On March 3, Soyuz 28 docked with the space station, and the four cosmonauts, according to Tass, began a weeklong planned program observing and photographing the surface of the Earth and oceans and undertaking unmanned medico-biological and technological experiments.[79] The various types of experiments were elaborated in some detail during the course of the mission.

Soyuz 28 was returned to Earth on March 10; Soyuz 27, with Romanenko and Grechko aboard, was brought down on March 16.[80]

Brezhnev praises cosmonauts

Opportunities abounded for the Soviets to extract political yield from these space exploits. And, except for the Romanenko-Grechko recordbreaking flight in which they downplayed comparisons with Skylab, they took full advantage. Consider first the Gubarev-Remek flight.

Many political themes surfaced in Soviet and Czech coverage of the Gubarev-Remek spaceflight. One persistent theme in the extensive and always politically relevant commentary was the inferred recognition of Soviet power and prestige; an expressed awareness of and renewed emphasis on the wisdom and correct judgment of the Soviet leadership and their political institutions; and the explicit or implied affirmation of established political and ideological positions. None seemed to be expressed in an outright boastful way but rather in a subliminal manner suggesting a self-assurance that comes with respect from others and a confidence that comes from demonstrated ability as when Brezhnev addressed the cosmonauts whom he was honoring. It gave Brezhnev "great satisfaction" to carry out the instructions of the CPSU Central Committee and the U.S.S.R. Supreme Soviet Presidium in presenting awards to the "space heroes": Romanenko, Grechko, Dzhanibekov, Makarov, Gubarev, and Remek. Continuing, he said:

> It is difficult to overestimate what was achieved during the manned flight of the scientific research orbital complex. With their 96-day flight, comrades Romanenko and Grechko surpassed the world record for a continuous stay in space. Two spacecrafts docked to an orbiting station is also unprecedented in the history of cosmonautics; and for the first time as well an automatic envoy from earth arrived at the orbital station—a cargo ship, with new reserves of fuel, materials, instruments, and even with the latest mail.
>
> All this for the first time, which means that everything was particularly complicated, particularly crucial. Everything was done excellently—the flight, the dockings, and the implementation of an extensive program of important scientific and technical research. The schooling and courage of the cosmonauts, the selfless labor of those who prepared the flights and insured the accurate and reliable work of the sophisticated space research complex has yielded results. A new major contribution has been made to implementing the decisions of the 25th CPSU Congress on the development of research into and the utilization of outer space for peaceful purposes. Here are the awards that have been earned:[81]

More direct political linkage between space and Soviet foreign policy was evident in the speech by Jozef Lenart, the Czechoslovak party leader, honoring the cosmonauts in Bratislava on May 2, 1978. Lenart concluded:

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[79] Moscow Tass in English, 2033 GMT, Mar. 3, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Mar. 6, 1978, pp. U2–U3.

[80] Shipler, David K. 2 Soviet Astronauts Return Safely After Man's Longest Space Flight. The New York Times, Mar. 17, 1978, p. A8.

[81] Moscow Domestic Service in Russian, 1000 GMT, Apr. 11, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Apr. 12, 1978, p. U1.

> By this flight, socialist countries have shown the world that the development of the national economy and the growth of the well-being of the people are the basic interests to which we want to subordinate all scientific, research and production potential. This is why our people speak so resolutely against the next round of the arms race which the American military-industrial complex wants to start. This is why we are against the neutron bomb, against the fact that socialist countries would be forced to produce it. We do not want to focus the skill and creativity of our scientists on destruction but on the creation of new values for a happy life of mankind on our earth. [applause] [82]

"Socialist Unity," a dominant theme

A dominant political theme, particularly in the coverage of the Gubarev-Remek spaceflight, was the emphasis on socialist unity and socialist internationalism. Soyuz 28 became a symbol of socialist unity and concrete evidence of the value of alliance with the Soviet Union. Thus, Gustav Husak, General Secretary of the Czechoslovak Communist Party, and Lubomir Strougal, Prime Minister of Czechoslovakia, declared in a congratulatory telegram to their counterparts in the Soviet Union, Brezhnev and Kosygin:

> The first joint flight in accordance with the Intercosmos program of cooperation is an unusually significant political social and scientific event which extends beyond the frontiers of both countries. At the same time it is another example of the closest and ever deepening fraternal cooperation between Czechoslovakia and the Soviet Union, among all the peoples of the socialist countries in the most varied spheres of human activity.[83]

Robotnichesko Delo, the Bulgarian daily, put it more succinctly: "The spacecraft now in space represents the fraternity and unity of the socialist family, socialist economic integration, socialist internationalism." [84]

Soviet and Czech awards to cosmonauts

Finally, space politics was perhaps given its greatest visibility in the rituals honoring the space heroes. Inherent in the elaborate ceremonies is official recognition at the highest party and state levels that space exploration is a valuable national enterprise and national asset. Symbolic, perhaps, of this appreciation of space exploration is the awarding of the most coveted medals to the cosmonauts. At a ceremony in the Kremlin on April 11, Brezhnev made the following awards: to Romanenko, the title Hero of the Soviet Union; to Grechko, the Order of Lenin and a second Gold Star medal; to Dzhanibekov, the title Hero of the Soviet Union; to Makarov, the Order of Lenin and a second Gold Star medal; to Gubarev, the Order of Lenin and a second Gold Star medal; and to Remek, the title Hero of the Soviet Union. Brezhnev then concluded with this appraisal of Soviet involvement in space exploration:

> I congratulate you, dear pioneers of the international conquest of space, on your lofty awards. I am sure that your initiative will be developed in a worthy fashion to the glory of the great socialist community . . . the supreme awards of our home-

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[82] Prague Domestic Service in Czech, 1730 GMT, May 2, 1978, in FBIS Daily Report: Eastern Europe, vol. 2, May 3, 1978, p. D4.

[83] Prague Domestic Service in Czech, 1730 GMT, Mar. 3, 1978, in FBIS Daily Report: Eastern Europe, vol. 2, Mar. 6, 1978, p. D2.

[84] Prague CTK in English, 1704 GMT, Mar. 3, 1978, in FBIS Daily Report: Eastern Europe, vol. 2, Mar. 6, 1978, p. D5.

> land which you have received are a just assessment of your selfless labor in space orbit and a recognition of your great services to science and to our fraternal peoples. We are sure that you will continue to tirelessly perfect your knowledge and experience and will always be ready to fulfill the tasks of the homeland in the study and use of space in the name of peace and progress on earth. From the bottom of my heart I wish you, dear comrades, good health, happiness and great new successes in your difficult work.[85]

At a ceremony in Prague Castle attended by the Czechoslovak party leadership and other Czechoslovak and Soviet dignitaries, Husak presented Gold Stars of Heroes of the Czechoslovak Socialist Republic to Romanenko, Grechko, Gubarev and Remek. Husak said that the Gubarev-Remek flight was symbolic of the fraternal relationship between the Soviet Union and Czechoslovakia. Elaborating on this theme, he went on to say:

> I believe this was summed up expressively by Leonid Brezhnev, when presenting high Soviet awards to you; he said that fraternal friendship and cooperation of countries of the socialist community went beyond the confines of our planet to the expanses of the universe. The space flight of an international crew is, above all, a manifestation of the internationalist policy of the CPSU and the Soviet state, of friendship and brotherhood of socialist countries. Presenting high Czechoslovak awards, I would like to wish you new successes, to wish new outstanding achievements in space exploration to Soviet science and technology.[86]

MATURITY AND RESTRAINT IN SOVIET SPACE POLITICS, EXCEPT FOR "HUNTER-KILLER SATELLITE" CHARGE

A review of the 4 months during the Romanenko-Grechko flight suggests a certain maturity and restraint in the Soviet approach to the politics of space. Absent is the crude, bombastic, propagandistic style so characteristic of the Khrushchev years. Except for the gross charges against the United States of militarizing space when it undertook a program to counteract the development of Soviet "hunter-killer satellites," Soviet behavior appeared to be politically restrained. Even when Romanenko and Grechko set a new space endurance record of 96 days in orbit thus outdistancing Skylab, the Soviet response was subdued and professional.[87] (Salyut 6 is now in its fourth year of operation; the present endurance record in space is 185 days.)[88] And in the case of the disintegration of the nuclear-powered Cosmos 954 over Canada (to be discussed in chapter 3) in January 1978 to the alarm of the West, the Soviet reaction was seemingly responsible, low-key and cooperative.

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[85] Moscow Domestic Service in Russian, 1000 GMT, Apr. 11, 1978, in FBIS Daily Report, vol. 3, Apr. 12, 1978, pp. U1-U2.

[86] Moscow Tass in English, 1616 GMT, Apr. 28, 1978, in FBIS Daily Report Soviet Union, vol. 3, May 1, 1978, p. D1.

[87] On the occasion of the recordbreaking flight, U.S. astronauts Gerald Carr, William Pogue, and Edward Gibson, the third crew of Skylab, sent a congratulatory telegram to Romanenko and Grechko. Director of the Johnson Space Center C. Kraft also extended congratulations to the Soviet scientists and space scientists participating in the Soviet orbital program. (Moscow Tass in English, 1200 GMT, Mar. 4, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Mar. 6, 1978, p. U5.) In a press conference on March 4, Academican Boris Petrov, Chairman of the Interkosmos Council, made the following comment: "The U.S. astronauts sent Georgi Grechko a cordial message of congratulations on having spent a longer time in outer space than any other spaceman. This is evidence of the spirit of good will and mutual understanding that has been cemented in the course of prolonged co-operation in space research between countries with different social systems." (Intercosmos Begins Manned Flights. New Times, March 1978, No. 11, p. 4.)

[88] Shabad, Theodore. Bigger Space Stations Are Soviet Goal. The New York Times, Apr. 12, 1981, p. E7.

Except for the "hunter-killer satellite" issue, therefore, Soviet behavior during this period could be described as reasonably correct. Serious efforts to communicate with the Soviet people on space matters, bringing in their leading scientists, engineers, and science commentators for this task, was a notable characteristic. Ceremonial occasions honoring successful cosmonauts seemed intended to achieve just that purpose and others in a collective effort that could reflect credit not only on the cosmonauts but also on the Soviet scientific community, Soviet political institutions, and their leaders. Such recent occasions were in marked contrast to the early days of the space race when award ceremonies were used, or better, abused, to denigrate the United States and its space program.[89]

In brief, the Soviet approach to the politics of space, except for the "hunter-killer satellite" issue, appeared to be responsible and restrained, if this selective period of analysis can be judged as reasonably accurate and representative. For the Soviets space exploration is clearly a serious business in which they have a deep and enduring commitment.

EMERGING TRENDS AND POSSIBLE EFFECTS

Taking a retrospective view of Soviet space politics during 1976–80, three overarching trends seem to be discernible, two negative and one positive. On the negative side, a growing complexity of the international environment that reduces the ability of the superpowers to assert their will, engage their power, and exercise their control over international events and the forces that create them; a decline of detente in Soviet-American relations that presages the possibility of cold war II should the relationship continue to disintegrate, diplomacy be debased, the SALT process terminated, and a full-blown arms race break out; and on the positive side, an emerging maturity in the Soviet management of space politics, except in military related space activities where they continue to sharply criticize the United States for trying to counter and neutralize Soviet advances in military space systems such as the "hunter-killer satellites."

The inability or unwillingness of the superpowers to restrain their rivalry and to assuage the emerging radical and destablizing forces such as international terrorism and Islamic fundamentalism adds to existing complexities and risks in world affairs. Under these conditions it becomes increasingly difficult for them, if they so wish, to establish mutually acceptable "rules of the game" upon which a reasonable and stable relationship can be based. Disintergration of detente further complicates international politics and lowers the threshold of risk. The effects could be to slow down, and perhaps prevent, further improvement in space relations since space politics, particularly international space cooperation, are determined, if the past can be a reliable guide, by the state of East-West political relations. Under Khrushchev space became a weapon of the cold war. Under Brezhnev in the early 1970's it became an instrument of detente. What it will be for the 1980's remains an open question. But it is worth noting that competition has probably advanced the exploration of space. Competition and rivalry within reasonable limits can be a stimulus to progress.

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[89] In a press conference on April 11, Romanenko made this gesture of respect to the American astronauts: "Preparing for carrying out this longest ever work effort in outer space . . . we took into account the experience of all the long flights made earlier by Soviet and American cosmonauts." (Moscow Tass in English, 1725 GMT, Apr. 11, 1978, p. U5.)

Chapter 3

Soviet Attitude Toward International Cooperation in Space *

SPACE COOPERATION: AN IMPERATIVE IN THE PRESENT ERA

COMMITMENTS IN ACCORD

AN EXPANDING UNIVERSE FOR SPACE ACTIVITIES

Space cooperation, at least on a selective basis, has become imperative in the present era. Once the sole concern of the superpowers, space now commands varying degrees of attention by virtually all nations in what has become an ever-expanding universe of space activity. The pacesetters of space exploration, the United States and the Soviet Union, have now been joined by such newcomers as the members of ERA, Russia's allies in Eastern Europe, and elsewhere in the Communist bloc, China, Japan, and India. And with the application of space systems to such variegated enterprises as communications, meteorology, the study of Earth resources, and oceanography, there is perhaps no nation in the world today that is not in some way affected by—indeed, that has not benefitted from—some aspect of space science and space exploration.[1] In some way space has touched the lives of all humanity.

Thus, Mr. Arnold Frutkin, NASA's Assistant Administrator for International Affairs and longtime participant in international space cooperation, could conclude in 1978:

> * * * international space activity is a constantly growing and highly rewarding activity—not only as the political and human intangibles may be concerned but in the hard areas of economics, agency programs, science and technology. Without question, we are getting increasingly substantial inputs to our national programs through cooperative projects as well as reimbursable arrangements.[2]

NASA Administrator Dr. Robert A. Frosch could forecast:

> In the international area, the 1980's offer the promise of additional opportunities for beneficial space cooperation with other countries. Many of the countries which

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* Prepared by Joseph G. Whelan, Senior Specialist in International Affairs, Senior Specialists Division, CRS.

[1] For an appreciation of the expansion of space activities internationally, see, U.S. Congress. House Committee on Science and Technology. World-Wide Space Activities. Prepared for the Subcommittee on Space Science and Applications by the Science Policy Research Division, Congressional Research Service, Library of Congress. 95th Cong., 2d sess. Washington, U.S. Government Printing Office, 1977. 607 pp. (House Doc. No. 95-352).

[2] U.S. Congress. Committee on Science and Technology. Subcommittee on Space Science and Applications. Hearings. 1978 NASA Authorization. 95th Cong., 1st sess. Washington, U.S. Government Printing Office, 1977, vol. 1, pt. 3, p. 79.

> entered space activities in the 1960's and 1970's have maturing capabilities and interests which continue to make them attractive potential partners on major projects—such as in planetary exploration—projects which might not otherwise be possible for NASA to fund. Moreover, developing countries which took limited notice of space a decade ago are increasingly interested and are seeking opportunities to participate in and share the benefits of space activity.[3]

And Mr. Kenneth S. Pedersen, Director of International Affairs in NASA's Office of External Relations, could predict, with some assurance:

> * * * Entering a new decade, we appear to have arrived at an important juncture in space activities. What was once the special preserve of two nations is in some sense within reach of many. More foreign countries, including developing nations, use and gain benefits from space than ever before.
>
> Foreign governments are increasing their investments in space and putting more emphasis on systematic long-range planning. As a result, they are more capable, useful partners, and more challenging competitors.[4]

Frutkin, Frosch, and Pedersen were speaking from the American perspective, but Soviet space officials could say very much the same thing.

For, given the expanding activity in space exploration and the growing demands for sharing in its benefits and costs, the spread of space cooperation globally is fast becoming a reality—indeed, a natural function—of international life. Thus Frosch observed:

> Perhaps the most profound effect of the space program has been the rapidly spreading realization that the human race is one body traveling through space on the same earthship. Thus it is natural that our national civilian space program is becoming ever more international in character.[5]

Less poetically, Jaroslav Kozesnik, President of the Czechoslovak Academy of Sciences, expressed the same sentiment at the 28th International Astronautical Congress (IAF) meeting in Prague:

> Space research becomes one of the important front lines of the scientific and technological revolution. However, owing to its complexity . . . scope and costs, it is not accessible to individual countries with the exception of superpowers. Therefore, international cooperation in the exploration of space gets naturally and inevitably on the agenda.[6]

SOVIET COMMITMENT TO COOPERATION

This expanding universe of space activity creates conditions that foster cooperation, and the two major space powers, realizing its political, economic, and scientific value, have long shared a common commitment to international space cooperation. Since the beginning of the Space Age, the Soviet Union has been committed to the principle of international cooperation in space.[7] This principle has been routinely proclaimed by the party leaders, space scientists, cosmonauts, and writers on space. Party programs, the highest declaration of official Soviet intent, aptly contain pledges of space cooperation.[8] In international forums, such as the United Nations and the International Astronautical Federation (IAF), Soviet representatives have reiterated their support for this principle. And in bilateral relations space cooperation has been featured prominently by Soviet leaders as a mechanism for solidifying friendship and expressing peaceful intent.

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[3] Dr. Frosch went on to enumerate the numerous international activities NASA had underway. See, U.S. Congress. Senate Committee on Commerce, Science, and Transportation. Subcommittee on Science, Technology, and Space. Hearings. NASA Authorization for Fiscal Year 1981. 96th Cong., 2d sess. Washington, U.S. Government Printing Office, 1980, pt. 2, pp. 866–867.

[4] Ibid., pt. 3, p. 1649.

[5] U.S. Congress. House Committee on Science and Technology. Hearings. 1980 NASA Authorization. 96th Cong., 1st sess. Washington, U.S. Government Printing Office, 1979, vol. 1, pt. 2, pp. 540–541.

[6] Harford, James J. Space Roles for the Less than Superpowers: Report on the 28th International Astronautical Congress, Prague. Astronautics and Aeronautics, vol. 15, December 1977: 18. "All large programs are becoming international," said H. Curien, head of France's Centre National d'Etudes Spatiales (CNES), at the opening forum of the Congress. This has the disadvantage of limiting competition, but it permits more countries to participate in space. Curien speculated, "We can fight the St. Matthew effect—the poor get poorer and the rich get richer—if we organize more programs like Spacelab, which offer integrated standardized payloads, making it easier for small countries to get involved."

But the movement from principle to performance has been slow in coming. Resistance to cooperation, particularly with the United States, was manifested early in the Space Age when scoring propaganda points against the capitalist West dominated the Soviet approach to space. Gradually, with the growing maturity of the Soviets in space, combined with favorable improvements in the strategic balance and an increased awareness of its real worth, politically, economically, and scientifically, this negative tendency gave way to a greater appreciation of the value of space cooperation.

Thus, Academician Y. Fyodorov, like the U.S. space officials noted above, recognized the reality that, "International cooperation in all . . . areas of outer space exploration and exploitation is gaining in scope and intensity." [9]

And Kapitonov, acknowledging this reality, could correctly give this description of growing Soviet involvement in space cooperation:

> The Soviet Union cooperates with many countries in space exploration, and this cooperation takes various forms. Joint stations for the optical monitoring of artifical earth satellites are sited on the territory of 17 countries in Europe, Asia, Africa and Latin America. The Soviet Union has been involved in major joint programmes for the exploration and use of outer space for peaceful purposes with France, the United States, India, and Sweden.
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> "Under international detente," Leonid Brezhnev said, "mutually beneficial scientific and technical contacts with the countries of a different social system have suc-

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[7] V. Kapitonov offered this perspective in concluding an article on Soviet space cooperation: "The Soviet Union, actively engaged in the study of space, has consistently advocated broad international cooperation in this sphere. The Soviet Union's invariable stand is that space should serve peace. On Apr. 12, 1961, the memorable day on which man first went up into space, these noteworthy sentiments were voiced by Moscow for the whole globe to hear: 'We regard the victories in the exploration of space as an achievement not only of our own people, but of all mankind. 'Ve are happy to place them at the service of all nations, for the sake of progress, the happiness and wellbeing of all men on Earth." (Kapitonov, V. International Cooperation in Space. International Affairs [Moscow], No. 5, May 1977:83.)

[8] The "Basic Guidelines for the Economic and Social Development of the U.S.S.R. for 1981-85 and for the Period Through 1990," approved at the 26th Party Congress in February-March 1981, contained the following statement on the Soviet commitment to the peaceful conquest of space: "Proceeding from the principles of peaceful coexistence of states with different social systems and from the need to strengthen relaxation of international tension, stable, mutually beneficial trade, economic, scientific and technological relations are to be maintained with the capitalist countries which show interest in cooperating with the Soviet Union. There is to be a continuation of the fulfillment of existing agreements and the conclusion of new ones in the field of implementing large-scale projects in the fuel, metallurgical and chemical industries and in other sectors of the national economy. Other ways are to be sought for developing cooperation with these countries. An active part is to be taken in the resolution of international problems in the sphere of raw materials, fuel and power, food, environmental protection, *the peaceful conquest of space*, the utilization of the resources of the world's oceans and the improvement, on a just and equitable basis, of international economic relations." (Moscow Pravda in Russian, Mar. 5, 1981, pp. 1-7, in FBIS Daily Report: Soviet Union, vol. 3, supp. 010, Mar. 10, 1981, pp. 46-47. Italics added.)

[9] Fyodorov went on to record the Soviet Union's extensive involvement in space cooperation both on a bilateral and multilateral basis. (Fyodorov, Y. The Use of Outer Space and Interests of Nations. International Affairs [Moscow], No. 7, July 1978: 14.)

cessfully developed, too. The cooperation with these countries covers a wide range of spheres: agriculture, transport, medicine, environmental protection, nuclear power industry, cosmic phenomena, and much else."

The U.S.S.R. and the other socialist community countries have greatly contributed to the use of scientific and technical achievements in space research and to promoting world peace for the benefit of humanity.[10]

The Soviet Union has thus been committed to the principle of space cooperation, and as this chapter will demonstrate, by the onset of the 1980's it had moved a long way from principle and rhetoric to solid performance within a limited number of partners.[11] But it must be clear at the outset that relatively few programs in the Soviet space effort are cooperative in nature, at least in the same sense as those carried on in the West. And like the Americans the Soviets maintain a substantial military space effort.

U.S. COMMITMENT TO COOPERATION

The U.S. commitment to space cooperation, like that of the Soviet's, was also made at the dawn of the Space Age. This commitment, mandated in the National Aeronautics and Space Act of 1958, became the law of the land.[12]

In carrying out this legislative mandate NASA has sought to combine the constructive contributions of other countries with the objectives of the U.S. space program. The result has been to establish common objectives between the United States and its cooperative partners. On this basis, according to NASA Administrator Frosch,

> NASA has cooperated formally with more than 30 countries in structured programs, such as the launching of foreign-built satellites, the flight of foreign experiments in our spacecraft and the development of major systems. We have had ground-based research and other types of association with scientists in more than 100 countries over the past 20 years.[13]

Prospects for the expansion of cooperative arrangements improved during the 1970's with increased aerospace capabilities, and accordingly with the allocation of greater resources to space in Europe, Canada, and Japan. This development confirmed the persistently optimistic outlook that the United States has maintained on the future of space cooperation. As Frosch observed:

> * * * the prospects are good. The history of cooperation is substantial; the benefits derived by all countries have been widespread and tangible. The United States and its foreign partners benefit in many ways from cooperation, * * * and we hope to go on cooperating in meaningful and substantive ways in the future. We have no preconceived notion of the form or the content of possible cooperation. The door is open to any reasonable proposal that a foreign nation wishes to offer.[14]

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[10] Kapitonov, International Cooperation in Space, p. 83.

[11] Periodically, the Soviet journal International Affairs publishes a chronicle summarizing their space activities, including joint ventures with other states. See, for example, International Affairs, vol. 7, July 1980: 134–135.

[12] For a discussion of the evolution of the U.S. approach to space cooperation, see, Marcia S. Smith. Basis for International Cooperation in Space. In, House Science and Technology Committee, World-Wide Space Activities, 1977, Ch. 6, pp. 485–499. For an appreciation of the extent of U.S. cooperation with other nations, see the tables reproduced on pp. 490–495.

[13] U.S. Congress. House Committee on Science and Technology. Subcommittee on Space Science and Applications. International Space Activities. Hearings. 95th Cong. 2d sess. Washington, U.S. Government Printing Office, 1978, p. 224.

[14] Ibid., p. 228.

SPACE COOPERATION IN AN INTERDEPENDENT WORLD

Both the Soviet Union and the United States are thus committed to the principle of space cooperation even if the cooperation is selective and competitive. Both have developed extensive international arrangements for cooperation, though the range of Soviet cooperation is overall rather limited in scope involving relatively few countries in comparison to the U.S. cooperative programs. Both are committed to the continuation of such arrangements and to an international agenda—"naturally and inevitably," as the Czech scientist said. For the reality of an expanding universe of space activity imposes upon them the necessity of cooperation, producing in both commitments in accord.

Hence the authors of the Congressional Research Service study on World-Wide Space Activities not only stated a simple truth but also could have spoken as much for the Soviets as for the Americans when they said: "One thing this study makes clear: Our Nation's future space activities will be intertwined with the future space activities of the other nations of the world." [15]

In the complex interdependent world of the 1980's the future space activities of the Soviet Union in many of its international aspects will be intertwined with those of other nations of the world, and most important with those of the United States.

PURPOSE AND DESIGN

The purpose of this chapter is briefly to throw some light on the Soviet attitude toward international space cooperation during the years 1976–80. No history of Soviet space cooperation is presented here but rather an attempt is made, through the examination of the Soviet experience as revealed in Soviet and Western sources, to suggest at best the Soviet attitude toward cooperation. Space cooperation has become so extensive, embracing so many countries and international institutions, that the enormity of the subject imposes on the researcher modest goals and should impose on the reader modest expectations.

Bilateral Soviet-American relations in space are examined in some detail in a later section. As the pacesetters in space exploration and the predominant powers on the international scene, the United States and the Soviet Union invariably affect the entire international system within which space cooperation takes place. Experience of the past bears out the generalization that in times of detente and easing of international pressures, space cooperation between the superpowers flourishes; in times of tension and cold war, cooperation deteriorates. Politics, in brief, is the thing: It determines the limits of space cooperation.

Other areas of Soviet space cooperation are examined later on. Soviet cooperation with their Interkosmos allies through the Interkosmos organization was extensive during the period under review. Cooperation among Communist nations, except for China, was highlighted by the inclusion of East European, Mongolian, Vietnamese, and Cuban cosmonauts in the Salyut-Soyuz missions. Cooperation with France, initiated by DeGaulle in the 1960's, was expanded appreciably. And cooperation with India was extended to a higher stage as India progressed in the development of its own space systems. These areas of cooperation, along with Soviet activities in other countries, are examined in varying degrees of detail, depending upon the extent of cooperation and the amount of data available. Soviet cooperation in the United Nations and other international organizations such as the IAF are only touched upon, no more than to indicate that the Soviets are active in these institutions and that sometimes they play an important role.

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[15] House Science and Technology Committee, World-Wide Space Activities, 1977, p. 1.

Generalizations drawn from the foregoing data are presented in a later section. An attempt is made here to extract some meaning from this experience of 5 years in Soviet space cooperation, emphasizing particularly those elements that can determine success or failure and suggest the future direction of Soviet space policy.

SOVIET-AMERICAN BILATERAL SPACE COOPERATION

TRENDS IN SPACE RELATIONS

CONTINUING SOVIET PROGRESS IN SPACE

In reviewing the period 1976–80, certain trends were discernible in Soviet-American space relations, and the most significant was the continuing Soviet progress in space in contrast to an apparent lagging U.S. effort. NASA officials persistently emphasized this trend in congressional hearings.[16] Department of Defense (DOD) witnesses routinely stressed the "aggressive" nature and the accelerated pace of the Soviets in space, particularly in their military programs.[17] American space specialists corroborated these judgments. Rumored development of a Soviet space shuttle to rival the U.S. Shuttle was cited as an example of continuing Soviet progress in space.[18] And the Soviets themselves gave the clear impression in their utterances that their programs were making the expected progress.[19]

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[16] On Jan. 26, 1976, Dr. George M. Low, Deputy Administrator of NASA, compared Soviet and American space activities in testimony before the House Science and Technology Committee and made this observation: "Looking in any area, except for the manned lunar landings, which we accomplished and they have not yet done, there is a great deal of comparability. There is a very active effort in the Soviet space program and I think we will see an increase and a continuing active effort, particularly in manned space flights, during the time when we have none until the Shuttle flies." (U.S. Congress. Committee on Science and Technology. 1977 NASA Authorization. Hearing. 94th Cong., 2d sess. Washington, U.S. Government Printing Office, 1976, vol. 3, p. 33.)

Dr. Alan M. Lovelace, Deputy Administrator of NASA, told the same committee on Feb. 6, 1979: "The Soviet Union continues a very vigorous manned program and as I would remind you, they established in 1978 the record for a manned presence in space of 180 days." (House Science and Technology Committee, Hearings, 1980 NASA Authorization, vol. 1, pt. 2, p. 553.)

[17] On Mar. 11, 1975, Dr. Malcolm M. Currie, Director of Defense Research and Engineering in DOD, told the Senate Aeronautical and Space Sciences Committee: "In recent years, the Soviet Union has maintained an aggressive space program with its major emphasis on support of military operations. While definitive numerical comparisons of their expenditures with our own are difficult to make, we believe that the resources which the Soviets have put into their military space programs over the past 3 years are much greater than our own commitments." (U.S. Congress. Senate Committee on Aeronautical and Space Sciences. NASA Authorization for Fiscal Year 1976 and the Transitional Period. Hearings. 94th Cong., 1st sess. Washington, U.S. Government Printing Office, 1975, pt. 1, p. 475.)

On Mar. 15, 1979, Dr. Willian J. Perry, Under Secretary of Defense for Research and Engineering, DOD, said: "The Soviet space program continues to be more military in character than that of the United States. There are gradually expanding civilian applications with participation in scientific satellite payloads by other nations and manned spaceflight in Soviet spacecraft by nations of other Communist bloc countries. However, these civilian and scientifically oriented flights are overshadowed numerically by the commitment to military objectives. Their massive military program is producing steady gains in reliability, sophistication, and operational capability." (U.S. Congress. Senate Committee on Commerce, Science, and Transportation. NASA Authorization for Fiscal Year 1980. Hearings. 96th Cong., 1st sess. Washington, U.S. Government printing Office, 1979, pt. 3, p. 1715.)

RETRENCHMENT IN U.S. SPACE ACTIVITIES

Retrenchment in U.S. space activities after the conclusion of the Apollo program was a second major trend during this period. A lull seemed to set in as attention focused on developing the Space Shuttle. Little attention was apparently given to the central question: Where was the United States going in space? Not until the much-delayed Shuttle was launched in 1981 did public awareness of progress in the U.S. space program surge forward, giving a boost to the potentialities of space cooperation.[20] Cutbacks in space were sharply criticized in this period, most recently those proposed by the incoming Reagan administration.[21]

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[18] Dr. Sheldon wrote: "The Soviet space program continues at a very high level, though 1977 fell one short of the number of successful flights conducted the year before. Both years represent the highest space activity of any country in any year." (Sheldon, Charles S. II. Soviet Space Activities in 1977. Air Force Magazine, vol. 61, March 1978: 77.)

Craig Covault, space editor of Aviation Week & Space Technology, made the following comment that was quoted by James E. Oberg, an American authority on Soviet space programs: "Explosive expansion of Soviet space program activity over the past several years, especially in the manned area, has been possible because the Russians have been providing their program with real funding increases of 3–5 percent per year, a sharp contrast to the U.S. congressional and presidential attitude toward the U.S. program since the end of the Apollo project. . . ." (Quoted in, Oberg, James E. Red Star in Orbit: Where the Russian Space Program Is Going. The Christian Science Monitor, July 13, 1981, p. 14.) The central theme in the Covault article was the Soviet development of a 12-man 220,000 lb. military-scientific space station.

Dr. Perry of DOD informed the Senate: "Based on open literature, human source reports and Soviet activities over the past years, we believe the Soviets are [deleted] a Reusable Space System (RSS). [Deleted]" (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, pt. 3, p. 1710.)

In a projection of future Soviet space activity, Aviation Week speculated that, "Soviet flight of a manned reusable winged space vehicle by about 1985 will provide the Russians with a high-launch-rate manned capability at less expense, although the new Soviet spacecraft will have nowhere near the capability of the U.S. space shuttle." (Soviets Increasing Space Activities. Aviation Week & Space Technology, vol. 112, Mar. 3, 1980, p. 83.)

More optimistic, and ominous (mistakenly so, as it turned out) was the appraisal that, "The undercurrents of Soviet-American space rivalry even suggest a possibility that the Soviets will launch their space shuttle shortly before the United States does, to reemphasize Soviet space leadership." (Forbrich, Carl A., Jr. Lt. Col. The Soviet Space Shuttle Program. Air University Review, vol. 31, May–June 1980:55–62.)

As recently as June 1981, a press report from Moscow, based on the judgments of Western space experts there, indicated that Soviet Kosmos 1267 that docked with Salyut 6 on the 19th represented an advance toward the development of a Soviet shuttle, perhaps a winged craft similar to the U.S. shuttle or a prototype "module" that would conform to already announced Soviet plans to piece together large, long-living orbital complexes in space. (The Christian Science Monitor, June 22, 1981, p. 3.)

[19] Academician Petrov made the following statement on future goals in Soviet space programs at a meeting commemorating the 20th anniversary of the launching of the first Sputnik: "Looking into the future, one can say that automatic devices in space, satellites and automatic stations will carry out more and more complex research of space near the earth, of the relationship between the sun and the Earth, the moon and the planets of the solar system, and will penetrate further and further into the reaches of the universe. Launches of biological satellites, both in the interest of working on fundamental problems of space biology and to resolve issues connected with preparation for long manned space flights, will continue. Orbiting stations will carry out long flights, receiving transportation vessels with crews of cosmonauts and unpiloted craft for delivery of cargo and supplementing reserves of fuel and life-support systems." (Moscow Domestic Service in Russian, 1405 GMT, Oct. 11, 1977, in FBIS 82.) Some of these activities were actually carried out in the next few years.

[20] NASA fully appreciated the potentialities of the Shuttle for space cooperation. During the 27th Congress of the International Astronautical Federation in October 1976, Dr. James C. Fletcher, NASA Administrator, noted that the first model of the Shuttle had rolled out in California just a month before. Clearly anticipating its international appeal, Fletcher said: ". . . I want to emphasize that the Shuttle is the work of many nations, and will provide opportunities for space participation for all the nations of the world. . . . We have already received flight requests from 12 countries to conduct 58 experiments. . . ." (The 27th IAF Congress, Anaheim, U.S.A.: Shuttle Shock Registers. Astronautics & Aeronautics, vol. 14, December 1976:50.)

Reflective of concern in some American quarters for retrenchment and its impact on public opinion was the appraisal in an editorial by The Christian Science Monitor of January 17, 1978 on the occasion of continuing Soviet successes with the docking of Soyuz 27 to Salyut 6. "The Soviet effort ought to give the United States pause," it said, and asked: "Is it in danger once again of falling behind the Russians in so important a scientific field?" "The Soviet are devoting far more of their resources to this effort than are Americans," warned the Monitor, adding: "The present lackadaisical public attitude toward space projects should not lull Congress into believing Americans can rest indefinitely on past achievements."[22]

This mood of concern for retrenchment seemed to prevail up to the eve of the launching of the Space Shuttle, Columbia, in the spring of 1981. As Columbia sat perched on the pad in Cape Canaveral waiting to be launched into orbit, a NASA spokesman expressed the hope that "it would give us a lift and bring our supporters out of the woodwork."[23]

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[21] In an analysis of cutbacks in the Carter administration's budget on space, Robert C. Cowen, science writer of The Christian Science Monitor, began: "After 20 years of space achievement, the once-affluent National Aeronautics and Space Administration is preoccupied with cutbacks and wondering where its future lies." According to Raymond A. Kline, Associate NASA Administrator for management, the era of "taking it out of fat and overhead" was over and that NASA managers would now have to cut into authorized programs, reduce support services, and even look at ways to cut back mission-oriented research. In short, NASA was marking time, as Cowen said, "trying to stay viable while the Carter administration finishes making up its mind where it wants to go in space." (Cowen, Robert C., Once-Affluent NASA Feels Strapped, Unsure of Aims. The Christian Science Monitor, Feb. 2, 1978, p. 1.)

Dr. Fletcher responded tactfully to congressional inquiries about the impact of budgetary cutbacks: "NASA is optmistic about the future of space flight and, as noted in my statement, we are continuing studies of potential future space flight missions and the development of new technologies, but due to fiscal constraints, the Advanced Programs area has not been allowed to develop as we would like." (House Science and Technology Committee, Hearings, 1978 NASA Authorization, 1977, vol. 3, p. 83.)

Senator Harrison H. Schmitt (R-N. Mex.) complained to Dr. Frosch in Senate committee hearings: "There is no commitment to the future of space in this country. There is a commitment to complete the Space Shuttle; beyond that, there is no commitment. I don't see one of any significance compared to the opportunties, compared to what other nations and other societies are going to be doing. . . . What it amounts to is that the major competitor we have on this planet, that is the Soviet Union, is extraordinarily interested in their future in space, and I see no comparable interest in the administration of the United States." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, 1979, pt. 2, pp. 927–928.)

Proposed cuts in the space budget by the Reagan administration generated sharp criticism in Western Europe. So serious was the matter that the European Space Agency formally protested the proposed cuts to the State Department, and France threatened to cease cooperating with the United States in international space missions. The cutbacks radically affected space programs in Western Europe that depended on U.S. cooperation. Jacques Blamont, chief scientist of the ESA, said: "We see this as a reverse trend of what used to be the case. The Russians now appear as a promoter of international cooperation, the Americans . . . as a demoter of cooperation." (O'Toole, Thomas. Proposed U.S. Space Budget Cuts Vex Allies. The Washington Post, Mar. 20, 1981, p. A8.)

[22] Factories in the Sky—Is the United States Falling Behind? (Editorial.) The Christian Science Monitor, Jan 17, 1978, p. 24.

[23] Van Slambrouck, Paul. Can U.S. Space Program Lift Off with Shuttle? The Christian Science Monitor, Feb. 18, 1981, p. 6. For a similar expression of concern and urgency, see Dennis Overbye. It's Time to Halt America's Retreat from Space. The Washington Star, Feb. 16, 1981.

That the American public did support the U.S. space effort was revealed in an Associated Press-NBC poll taken on Aug. 10 and 11, after the successful flight of Columbia. Sixty percent of those polled thought the United States was not spending enough or was spending about the correct amount of money on its space program, and 66 percent believed that the Shuttle program was a good investment; 49 percent said the emphasis should be placed primarily on national defense, while 32 percent favored scientific exploration, 10 percent cited both and 9 percent were not sure. (The New York Times, Aug. 19, 1981, p. A20.)

COMPETITION AND COOPERATION IN SPACE

Acceleration of Soviet activities in space and retrenchment by the United States tended to encourage a renewed awareness among some interested Americans of their rivalry with the Soviet Union in space. Yet, this tendency was counterbalanced with another; namely, an inclination on both sides toward cooperation. Competition and cooperation in space was thus the third major trend in this period under review.[24]

The competitive side of the relationship was stressed in policy statements by NASA officials who consistently emphasized the importance of maintaining space leadership;[25] in assessments by DOD officials underscoring Soviet progress (and thus threat to the United States) in their military space programs, notably development of the ASAT system;[26] and in the opening of U.S. space relations with Soviet Russia's foe, the People's Republic of China. The cooperative side was expressed in the restatement of commitments to space cooperation by both sides and made manifest by the visible evidence examined below in this section, particularly the signing of formal agreements on space cooperation and the carrying out of cooperative programs.

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[24] Mr. Kenneth S. Pedersen, Director, International Affairs, Office of External Relations, NASA, well expressed this combination of competition and cooperation in space when he said: "Looking ahead, I find that the one theme that is constantly recurring is that of international cooperation and competition and how these two forces play against one another. . . . we are seeing a maturing of foreign space capabilities and we are seeing a widespread international recognition of the benefits of space activity." Turning to the other major space power, he stated that the Soviet Union "will continue to present challenges to U.S. leadership and possible opportunities for cooperation. I have already briefly touched on the cooperation that we have had with them, primarily in the scientific area. The extent to which the U.S.S.R. becomes a competitor in the world space market will depend largely upon their own policies." Pedersen seemed to be referring to competition in the larger international sense than just between the Soviet Union and the United States. (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 3, p. 1653.)

[25] From examining the NASA authorization hearings for 1976–80, it is clear that on the U.S. side space leadership is a very important goal. Much of the questioning was centered around the idea of competition and leadership. Almost as a matter of routine NASA officials categorically stated U.S. policy of maintaining leadership in space, particularly in science and technology. For example, in Senate hearings Dr. Fletcher said: "I would sound one note of caution . . .: the United States is not alone in exploring and exploiting the space environment. To retain our leadership in science, technology, and applications, to maintain our national security, and to develop the full potentials of space in the face of determined competition will call for our very best national efforts." According to Fletcher, "The importance of our retaining leadership in science and technology cannot be overemphasized, for science and technology represent, in my judgment, the cornerstone of our economic well-being." (U.S. Congress. Senate Committee on Commerce, Science, and Transportation. NASA Authorization for Fiscal Year 1978. Hearings before the Subcommittee on Science, Technology, and Space. 95th Cong., 1st sess. Washington, U.S. Government Printing Office. 1977, pt. 2, p. 764.) For institutional emphasis on the importance of leadership in space, science, and technology, see, U.S. General Accounting Office. U.S. Must Spend More to Maintain Lead in Space Technology. Washington, Jan. 31, 1980, in, U.S. Congress. Senate Committee on Commerce, Science, and Transportation. NASA Authorization for Fiscal Year 1981. Hearings before the Subcommittee on Science, Technology, and Space. 96th Cong., 2d sess. Washington, U.S. Government Printing Office, 1980, pt. 3, pp. 1310–1315.

[26] Dr. Perry gave this word of caution in Senate hearings that was fairly consistent with his predecessor's, Dr. Currie: "The Soviet space program is under military control and is dominantly military in character. An unequivocal priority is given to the use of space for the purpose of strengthening the Soviet armed forces. The Soviets are attempting to compete—in a military sense—in space. The U.S.S.R. has invested significant resources in development and deployment of systems for force support." (U.S. Congress. Senate Committee on Commerce, Science, and Transportation. NASA Authorization for Fiscal Year 1979. Hearings before the Subcommittee on Science, Technology, and Space. 95th Cong., 2d sess. Washington, U.S. Government Printing Office, 1978, pt. 3, p. 997.)

AFGHANISTAN AND THE DOWNTURN IN RELATIONS

The final trend apparent in this review of 5 years of space cooperation was the downturn in relations brought on by the Soviet invasion of Afghanistan and the adverse effects of this aggressive action on space cooperation. The human rights issue, so prominently featured in the Carter administration and directed largely against the Soviets, had created strains in political relations. This issue was tangentially connected with space cooperation through scientific exchanges. The opening of space relations with China and particularly the granting of de jure recognition and the establishing of formal diplomatic relations also had a negative impact. But it was the invasion of Afghanistan, a "watershed event," that caused a sudden and precipitious downturn in U.S. relations with Moscow. Space cooperation suffered as a consequence, and relations, now 2 years after the invasion, have yet to be restored to their previous state of reasonable normalcy.

PLANS FOR FOLLOW-ON OF ASTP

ASTP, THE HIGHPOINT IN SPACE COOPERATION

In retrospect, the Apollo-Soyuz test project (ASTP) of July 1975 was the highpoint in the brief history of Soviet-American space cooperation.[27] By all accounts, ASTP was a landmark in Soviet-American space cooperation, as U.S. Astronaut Vance D. Brand, a crewman aboard Apollo, put it; [28] a "major cooperative achievement," according to Dr. Malcolm R. Currie, Director of Defense Research and Engineering, Department of Defense; [29] and in Frutkin's estimation, a "complete success from the point of view of an international cooperative effort." [30] For Soviet space specialists, ASTP "has been and remains," as Mikhail Chernyshov of the Soviet Novosti Press Agency said in a retrospective glance, "an example of the fruitful quest for the spheres of the joint effort, for what unites rather than disunites mankind." [31] John F. Yardley, NASA's Associate Administrator for Space Flight, took full measure of ASTP's achievements, politically and scientifically, in these few words:

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[27] For a review of the project, see Senate Aeronautical and Space Sciences Committee, Soviet Space Programs, 1971-75, pp. 100-120. See also, House Science and Technology Committee, Hearings, 1977 NASA Authorization, 1975, vol. 1, pt. 1, pp. 820-825 and pp. 847-850.

[28] Moscow Tass in English, 2020 GMT, July 14, 1977, in FBIS Daily Report: Soviet Union, vol. 3, July 15, 1977, p. B5.

[29] U.S. Congress. Senate Committee on Aeronautical and Space Sciences. NASA Authorization for Fiscal Year 1977. Hearings. 94th Cong., 2d sess. Washington, U.S. Government Printing Office, 1976, pt. 3, p. 2076. Currie continued: ". . . we learned very much technically from the Apollo-Soyuz experiment, so the achievement for us would have to be in terms of national cooperation, larger national purposes."

[30] House Science and Technology Committee, Hearings, 1977 NASA Authorization, 1976, vol. 1, pt. 2, p. 646. Frutkin continued: "Here we were working with a country whose interest in the world doesn't always square with our own, a country which is often not the easiest one to work with, but nevertheless, very far-reaching commitments were made for this project and all were completed satisfactorily." For further commentary by Frutkin on the value of ASTP, see vol. 1, pt. 3 of these hearings, pp. 298-299 and 302-303.

[31] Chernyshov, Mikhail. Russian Report: International Cooperation in Outer Space: Two Approaches, Two Strategies. Space World, vol. Q-10-202, Oct. 1980:17.

> * * * all the joint operations were very beneficial in learning how to work with another country. The experiments were very successful, and we were able to, in our small way, improve relations between the United States and the U.S.S.R.[32]

ASTP was thus a great achievement and so was considered by both sides. Success required the most intimate forms of technical and political cooperation; this was done; and the result was to score a big plus for space cooperation. Detente in Soviet-American relations made ASTP possible, and ASTP's success gave detente another push forward. The task facing space planners in the post-ASTP period was how to capitalize on this favorable environment in order to broaden and deepen space cooperation.

FUTURE DIRECTION OF COOPERATION: A FIRST STEP

Space officials did not delay for long the task of plotting the future course of cooperation. Speaking for NASA, Frutkin noted that future cooperation with the Soviets was "very much on our minds" during 1975. NASA had contemplated the definition of a follow-on project to ASTP before that program itself had been completed. But the Soviets had other thoughts. They wanted to complete that project first before committing to a follow-on. NASA did succeed in discussing the matter "quite frankly with them" in May 1975 and, as Frutkin said, "did find a strong feeling, sharing ours, that the dynamics of this cooperation should be preserved." [33]

Informal discussions on what forms of cooperation might be undertaken in the post-ASTP period progressed well during 1976 and culminated in talks at NASA headquarters in October 1976. At that meeting the conferees established a "meeting of minds" that studies should be undertaken to structure cooperative activities, as Frutkin reported, in the following areas:

> (1) Studies of the joint operation of the Shuttle/Soyuz/Salyut spacecraft for scientific and applications objectives of merit to be agreed, such as identifying and monitoring atmospheric pollution constituents. This program would be designed to benefit from the flexibility of the Shuttle and the longer staytime of Salyut.
>
> (2) Studies of the objectives that would be served by a space platform and of the feasibility of developing such a space platform bilaterally or multilaterally.

The next step was to reduce this "meeting of minds" to an agreement that would establish appropriate study groups for these specific areas and set schedules and milestones for their work. The study groups were expected to report back their recommendations for review before any commitment to programs or expenditures would be made.[34]

Apart from considerations on this specific program, the direction of cooperation moved along lines already set down in the agreement of 1972; namely, delivery of Soviet lunar samples; mutual briefings on Venera 9 and 10 and Viking landers on Mars; U.S. participation in the Soviet experiments aboard their biological satellite; continuation of the joint project for remote sensing of crops and vegetation; and tests to cross-calibrate NASA and Soviet meteorological rockets.[35]

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[32] Senate Aeronautical and Space Sciences Committee, Hearings, NASA Authorization for Fiscal Year 1977, 1976, pt. 2, p. 994. Yardley stated: "The primary objectives of the program were met . . ., including rendezvous, docking, crew transfer, and control center and crew interaction. In addition, all of the secondary objectives of the experiments were completed, as well as the major objectives of the experiments." (p. 1021)

[33] House Science and Technology Committee, Hearings, 1977 NASA Authorization, 1976, vol. 1, pt. 2, pp. 648-649.

[34] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, 1977, pt. 2, p. 815.

A specific direction for future cooperation in the post-ASTP period was laid out in the Soviet-American agreement on space cooperation of May 1977. Why such an agreement should be concluded, particularly with respect to plans for a Shuttle/Salyut mission, was perhaps best expressed by Academician B. N. Petrov, chairman of the Interkosmos Council, who described such pooling of efforts as "a logical continuation of the successful 'Soyuz' and 'Apollo' flight."[36] Frutkin was similarly optimistic about building a cooperative arrangement based upon capabilities developed in ASTP.[37]

FORMAL SOVIET-AMERICAN SPACE AGREEMENTS, May 1977

AGREEMENT BETWEEN ACADEMY OF SCIENCES AND NASA, MAY 11, 1977

Soviet-American space agreements were concluded in May 1977 that established the basis for space cooperation in the post-ASTP period. Discussions were held in Washington during October 19–22, 1976 between delegations headed by Soviet Academician Petrov and Deputy Administrator of NASA Dr. Allan M. Lovelace. The agreement was signed on May 11, 1977. It established the conditions for the Shuttle/Salyut joint manned spaceflight program.[38]

By the terms of this agreement (for text, see appendix II), the Soviet Academy of Sciences and NASA agreed to study the "Objectives, Feasibility and Means of Accomplishing Joint Experimental Flights of a Long-Duration Station of the Salyut-Type and a Reusable 'Shuttle' Spacecraft (Salyut-Shuttle Program)." The long orbital staytime of Salyut and the unique capabilities of the Shuttle, notably its ability to ferry people and large quantities of supplies in a reusable craft, "commend their use for joint scientific and applied experiments and for further development of means for rendezvous and docking of spacecraft and stations of both nations. . . ."

Two joint working groups were established: One for basic and applied scientific experiments, the other for operations. The agreement scheduled the activity of the joint working groups in two phases and directed them to proceed on the assumption that the first flight would take place in 1981, though the final date would be set during the mission as it progressed. Both sides also agreed to establish a joint working group of specialists "for preliminary consideration of the feasibility of developing an International Space Platform on a bilateral or multilateral basis in the future." No commitments were made beyond this stipulation.[39]

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[35] Ibid.

[36] Moscow Pravda in Russian, May 27, 1977, p. 4, in FBIS Daily Report: Soviet Union, vol. 3, June 7, 1977, pp. B3–B4.

[37] "There is every reason to believe," he told a House committee, "that what we will do here is build on the capabilities developed in Apollo-Soyuz and look to applying it in future programs involving the Shuttle and the Salyut, or whatever system the Soviets are flying in that time period." (House Science and Technology Committee, Hearings, NASA Authorization Hearings Fiscal Year 1977, 1976, vol. 1, pp. 649–650.)

[38] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 3, pp. 933–935.

[39] Ibid., pp. 934–935.

SOVIET-AMERICAN SPACE AGREEMENT, MAY 24, 1977

On May 18, 1977 in Geneva, Soviet Foreign Minister Andrei Gromyko and Secretary of State Cyrus R. Vance signed an agreement on space cooperation. The agreement was to enter into force on May 24, 1977 and remain in force for 5 years. (For text, see appendix II).

The agreement contained the following stipulations:

The parties pledged to continue cooperation in a wide range of activities in space science and space applications, such as meteorology and the exploration of near Earth space, the Moon and planets; and particularly to fulfill the requirements of the NASA-Soviet Academy of Sciences agreement of January 21, 1971, as periodically renewed; they agreed to cooperate through such mechanisms as mutual exchange of information and delegations, meetings of scientists and specialists, and in other ways agreed upon, including the setting up of joint working groups to carry out specific cooperative programs; they agreed to "take all necessary measures" to further cooperation in manned spaceflight and to achieve scientific and practical objectives, including joint flights of compatible docking and rendezvous systems derived from the ASTP experiment and as prescribed in the NASA-Soviet Academy of Sciences agreement of May 11, 1977; and finally, they agreed to encourage efforts to resolve problems of international law on the peaceful use of space with a view to strengthening the legal order in space and developing international space law.[40]

This agreement established the basis for Soviet-American space cooperation through the early 1980's. It was a very important political instrument because it insured continuity in Soviet-American space relations.

SOVIET RESPONSE TO AGREEMENT

Predictably, the Soviets acclaimed the new space agreement as evidence of the value of detente and of space exploration for peaceful purposes in the service of mankind.

New Times, the Soviet foreign policy weekly with a global circulation, published the text of the agreement for the benefit of its readers.[41]

In a retrospective glance, Academician Mstislav Keldysh, head of the Soviet Academy of Sciences, described the near decade of Soviet-American space cooperation as "fruitful," and then summarized the new agreement approvingly.[42]

Academician Petrov summarized the agreement in a Pravda interview, and recalling the success of international cooperation in the peaceful uses of space in Interkosmos, expressed the hope that "the new agreement will mean even greater progress in this direction."[43]

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[40] Ibid., pp. 933–934.

[41] New Times (Moscow), No. 22, May 1977:32.

[42] Moscow Tass in English, 1522 GMT, May 24, 1977, in FBIS Daily Report: Soviet Union, vol. 3, May 26, 1977, vol. 3, pp. B3–B4.

[43] Moscow Pravda in Russian, May 27, 1977, in FBIS Daily Report: Soviet Union, vol. 3, June 7, 1977:B3–B4.

On the 2d anniversary of ASTP in July 1977, Soviet Cosmonaut Valeriy Kubasov, a participant in the mission, acclaimed the new agreement as a "logical continuation" of the Soyuz-Apollo flight. Americans as well as Soviet citizens saw in ASTP, he said, "the manifestation of good will of the two countries and the beginning of great cooperation of nations in space." [44]

Soviet scholars also wrote enthusiastically about the new space agreement.[45]

EPILOGUE: SHUTTLE/SALYUT HELD IN ABEYANCE

Plans under discussion

Planning for a joint Shuttle/Salyut mission went forward very quickly.[46] During November 14-17, 1977, Soviet and American space officials conferred in Moscow to discuss the potentialities of a cooperative Shuttle/Salyut program.[47] Scientific and technical discussions were carried on by two working groups, the experimental group and the operational group. Both groups considered both the feasibility and the means for carrying out a joint Shuttle/Salyut experimental program. The Soviet participants transmitted 11 concept proposals to the U.S. side for further consideration. The operations group identified three basic assumptions for planning the joint project. Three possible operating modes, or a combination of these, for conducting experiments using the Shuttle/Salyut were identified.[48]

Both sides agreed that the joint working groups would meet in the United States in April 1978 to continue planning. Additional meetings were expected: In July 1978, to discuss the selection of a possible experimental program and division of labor between both sides; and in October 1978, to decide on recommendations for a program of scientific experiments and to reach a conclusion on the scientific merits and technical feasibility of such a program.[49]

Perhaps the American approach to the Shuttle/Salyut project was best summed up by Dr. Noel W. Hinners, NASA's Associate Administrator for Space Science, when testifying before the House Science and Technology Committee on February 2, 1978, he said:

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[44] Moscow Tass in English, 1241 GMT, July 13, 1977, in FBIS Daily Report: Soviet Union, vol. 3, July 14, 1977, p. B9.

[45] See, for example, G. S. Khozin. New Space Exploration Agreement. U.S.A.: Economics, Politics, Ideology, No. 8, September 1977, JPRS 69794, Sept. 15, 1977: 61-67. Referring to the economic value of the agreement, Khozin wrote: "In this connection, it would be difficult to overestimate the significance of the new Soviet-American agreement on cooperation in space exploration: the united efforts of specialists from both countries in space research and utilization will aid in preventing duplication in several fields and will raise the profitability level of space technology" (p. 65). For a discussion in the legal context, see, Y. Kolosov, D. Sc. (Law). Space and International Law. International Affairs (Moscow), No. 8, August 1977: 54-61.

[46] For commentary on preliminary discussions prior to reaching the May agreement, see Frutkin's testimony in, House Science and Technology Committee, Hearings, 1978 NASA Authorization, 1977, vol. 1, pt. 3, pp. 58 and 90. See also the response to an inquiry on the mission in vol. 3, p. 214.

[47] This account of the meeting is based on Dr. Noel W. Hinners' testimony and report to the House Science and Technology Committee on Feb. 2, 1978. See, House Science and Technology Committee, Hearings, 1979 NASA Authorization, 1978, vol. 1, pt. 2, pp. 1415-1416. Dr. Hinners was the Associate Adminstrator for Space Science in NASA.

[48] Ibid.

[49] Ibid., p. 1416. For other commentaries and reports by Hinners, see, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 1, pp. 117, 289-290, 369-370, and 474-480.

Now, as to Soviet cooperation, it is useful to inform the committee where we stand on the Shuttle/Salyut discussions.

You have read about this in the press. We are investigating with the Soviets a potential program of cooperation, using to our mutual advantage, the great weight carrying capability of the Shuttle and its capability to revisit and supply and the long-duration staytime of the Soviet Salyut space station.

They have a station in Earth orbit now that may be capable of lasting 1½ years to 2 years. We have nothing on the horizon approximating that staytime duration in space.

Potentially, there is an area of mutual benefit here, utilizing the long staytime and using our ability to resupply for a joint program.

We have stated, categorically, that any potential joint program must be based on a sound science and technology base. A joint study is underway the first phase of which will probably culminate next October. That phase is to look at the areas of mutual scientific interest, to develop candidate science programs and to determine whether or not there is, indeed, mutual benefit and mutual contribution on both sides. We are looking to a program approximating a 50-50 split of resources. Only then would we make recommendations to the NASA Administrator or the Soviet Academy as to whether there is a useful program.

I am looking on the science as competitive with the other activity we have planned for space science. For me to be convinced there is a good program requires that the science proposed be competitive with what we are now considering our free flyer and Spacelab missions.[50]

Plans for a Shuttle/Salyut project were thus in gestation. The project made sense: Each side had something to contribute, and something to gain. The characteristics of each spacecraft complemented the other. The idea had a sound scientific and technological basis. The Soviets were anxious to undertake this mission, but NASA was proceeding carefully as Hinners' statement suggests, to insure that such a mission would bestow solid benefits in science and space applications.[51]

Momentum arrested

But international politics intruded in 1978-79 to arrest the momentum toward final agreement on the Shuttle/Salyut mission. The human rights issue had already created severe strains in political relations by 1978. These strains were further aggravated by favorable developments in U.S. relations with China. On January 1, 1979, the United States and China established formal diplomatic relations. Annoyed by this further evidence of the United States "playing the China card," the Soviet Union responded by delaying momentarily the conclusion of the SALT II agreement. But final U.S. approval of the agreement, after the formal signing in June 1979, became doubtful with the publication of official evidence purporting to show the presence of a Soviet brigade in Cuba. Critics of SALT effectively used this report to quicken traditional American distrust of the Soviet Union, particularly with respect to its aims in Cuba.

The Soviet invasion of Afghanistan in December 1979 dashed all hopes for Senate approval of SALT, at least for some time. In the aftermath Soviet-American relations deteriorated sharply. To show its displeasure the United States shelved the SALT agreement

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[50] House Science and Technology Committee, Hearings, 1979 NASA Authorization, 1978, vol. 1, pt. 2, pp. 1561-1562. For comments on progress in the Shuttle/Salyut program by Mr. Norman Terrell, Director of International Affairs of NASA, see, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 3, pp. 935-936 and 951.

[51] New Designs Spur Soviet Space Activity. Aviation Week & Space Technology, vol. 108, Mar. 13, 1978: 77.

(though along with the Soviets, the United States pledged to abide by both SALT I and II agreements) and took other punitive measures against Moscow. Space relations, with some exceptions, were to suffer accordingly.

Thus Dr. Frosch had little good news to report in his appearance before the Senate Commerce, Science, and Transportation Committee on February 21, 1979. He reminded the committee of the space agreement of 1977 that provided for the creation of two joint working groups. It was anticipated, he said, that these groups would meet during 1978 to study jointly the feasibility of a Shuttle/Salyut mission. But in Frosch's words, "the United States decided to carry out a further detailed interagency review of the matter and, therefore, requested a postponement of these meetings. To date no further United States-U.S.S.R. meetings on the subject have been held." The next step, he continued, would be for "the United States to decide whether it wishes to carry out a joint study with the Soviets and, if so, what experiments would be considered for a joint mission." This was the status of the project as of February 1979: It was "undergoing an interagency review" and at that time no commitment had been made to go beyond this point.[52]

Little has apparently changed in the status of the Shuttle/Salyut project since then. On February 6, 1980, Dr. Frosch told the Senate commitee considering NASA's authorization that discussions of the working groups "have been in abeyance for something over a year and a half." He described the status of the groups as being "simply at a state where we were in between activities." NASA authorities had given some thought to holding a meeting of one of the groups in October (presumably October 1979), but nothing was formally scheduled. As Frosch explained, "we will be conferring with the State Department with regard to what the national policy view will be and what we ought to do next." [53]

Senator J. James Exon described the state of relations as one of an "arms-length arrangement that we'll more or less continue." Frosch gave assurances that some activities, such as search and rescue operations, would not be affected by this "arms-length arrangement." But he added: "The direct scientific activities may be affected but not immediately, since there was no immediate action to be taken anyway." [54]

The Soviets took a realistic view of the lack of progress in the Shuttle/Salyut project. In explaining the obstacles to progress,

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[52] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, 1979, pt. 2, p. 934. The feeling of inconclusiveness in carrying out the space agreement was conveyed in the response of Mr. Norman Terrell, Director of International Affairs, NASA, when asked to comment on the possibility of cooperation in the development of large-scale power facilities in space. He replied: "I don't think we are at this point yet in our cooperation. There is a provision in the May 1977, Academy-NASA agreement for the possibility of looking together at joint space station efforts." Terrell emphasized that, "There has been no direction toward implementing it by either side. Our own internal thinking on that subject is not at a point that we could fruitfully get into anything with the Soviets. Apparently, they are in the same position." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 3, p. 944.) For other commentaries on the status of Soviet-American space relations in the context of the 1977 agreement, see, U.S. and Russia Consider Shuttle/Salyut Flight. Flight International, vol. 113, Apr. 1, 1978:939, and Eduard A. Kanstantin. The Salyut 6 Mission: Soviet Rehearsal for a Permanent Space Station? Interavia, vol. 33, November 1978:1081.

[53] Senate Committee on Commerce, Science, and Transporation, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 2, p. 1055.

[54] Ibid., p. 1055.

Cosmonaut Alexei Leonov, commander of the Soyuz crew participating in ASTP, cited first the delays in the shuttle program that advanced liftoff from 1979 to 1981. And then he explained the second obstacle:

> Another thing troubling us is that, as a result of recent developments on the international scene, the 1977 agreement, though legally not cancelled, is practically no longer being carried out. This cannot but tell on our scientific ties.[55]

The promise of the space agreements of May 1977 was thus not realized, at least that part of the agreement dealing with joint ventures in manned spaceflight. For nothwithstanding the collapse of expectations for a Shuttle/Salyut mission, forms of cooperation were carried foward in other areas of space science and space applications.

Cooperation in Planetary Activities

CONFERENCE ON COSMOCHEMISTRY OF PLANETS AND MOON, JUNE 1974

An exception to the general pall that hung over space relations during the period under review was Soviet-American cooperation in planetary activities. In this case, Soviet and American scientists had something to build on. During the heyday of detente, nearly 40 American and 75 Soviet scientists exchanged ideas in a 4-day conference held in Moscow during June 1974. The subject of the conference was the cosmochemistry of the planets and the Moon.

Dr. Hinners termed this "an excellent conference" in which a great deal of information and ideas was exchanged. Rewarding personal contacts took place among the scientists, preprints were circulated, and "cross-pollination" occurred among scientists of different disciplines. Many of the participants had carefully prepared extensive review papers which, in Hinners' words, "summarized and synthesized a great deal of existing and recent results instead of merely presenting new data."[56] The general theme of the conference was comparative planetology and the desirability of studying other planets to increase an understanding of the Earth, its formation, chemistry, mineral distribution, and the evolution of its atmosphere and hydrosphere.[57]

In brief, this conference seemed to be a model for space cooperation. As Hinners reported: "Many of the American scientists felt that the sharing of data and theories at the conference was a step toward improved cooperation in space science between the United States and the U.S.S.R. in a kind of scientific detente."[58]

VENERA 9 AND 10, 1975

The same spirit of accommodation was carried into the Venera 9 and 10 missions. Both were launched on June 8 and June 14, 1975, respectively. Venera 9 soft-landed on the surface of Venus on October 22, Venera 10 on October 25. Information about the atmosphere of Venus and the first pictures of the Venusian surface were relayed back to Earth. This achievement was remarkable, and the Venera findings surprising.[59]

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[55] Yenyutina, Lyudmila. Space: July 17, 1975, an interview with Alexei Leonov. Soviet Life, No. 9, September 1980: 43.

[56] For a full report on the conference, see Hinners' testimony in, Senate Aeronautical and Space Sciences Committee, Hearings, NASA Authorization for Fiscal Year 1976 and the Transitional Period, 1975, pt. 1, p. 336.

[57] Hinners testimony, Senate Aeronautical and Space Sciences Committee, Hearings, NASA Authorization for Fiscal Year 1976, 1975, pt. 2, p. 438.

[58] Senate Aeronautical and Space Sciencies Committee, Hearings, NASA Authorization for Fiscal Year 1976 and the Transitional Period, 1975, pt. 1, p. 336.

The United States had plans underway to probe Venus in 1978 with its Pioneer Venus. American specialists were, therefore, especially interested in getting as many details as possible about the Soviet mission, particularly information on the angles of entry into its atmosphere.[60] In November 1975, a month after the landings, Dr. Hinners requested in writing a briefing from the Soviets before the end of the year. It was important to make adjustments in the American program should the Soviet experience suggest that changes be made. No formal response came from the Russians.[61] But in the following months information began to appear in space journals. And the Russians promised to give a detailed account of their findings at the Committee on Space Research (COSPAR) meeting scheduled for Philadelphia in June.[62]

At the Venera session in Philadelphia the Soviets did come forth with information on the Venera mission in the form of a report by Mikhail Marov (ostensibly written by Academician Keldysh) and in private meetings with NASA scientists. Computer enhanced photographs of the surface were shown, and NASA was promised copies.[63]

The Soviets fulfilled this promise; they did pass on the pictures to NASA. Hinners described them as "good pictures of the surface, which have some surprises." For NASA this new data was very important: It gave them confidence, Hinners said, "confidence that the basic engineering models of the Venus atmosphere are correct." [64]

Yet the Soviets were not quite so forthcoming with information as might be apparent here. When probed on this matter, Dr. Hinners responded, attributing Soviet failure to cooperate sometimes to technical deficiencies rather than to any hostile intent:

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[59] Smith, Marcia S. U.S.-U.S.S.R. Agreement for Cooperation in Space. In, U.S. Congress. House Committee on International Relations. Technology Transfer and Scientific Cooperation Between the United States and the Soviet Union: A Review. Prepared for the Subcommittee on International Security and Scientific Affairs by the Congressional Research Service, Library of Congress. 95th Cong., 1st sess. Washington, U.S. Government Printing Office, 1977, pp. 117-118. (Committee print.)

[60] Ibid. On the matter of complementarity of programs, Hinners noted: The Pioneer Venus program "complements what the Russians have done with their highly successful Venera 9 and 10 missions. They focused on obtaining surface data on Venus. We are not taking pictures and measurements on the actual surface, but are concentrating on the atmospheric profile and on the orbital science." (House Science and Technology Committee, Hearings, 1977 NASA Authorization, 1976, vol. 1, pt. 2, p. 502.) In his formal statement, Dr. Hinners explained: "Veneras 9 and 10 are following an expected U.S.S.R. course of emphasis on surface investigations. The Soviets are steadily increasing their useful stay times on the surface of Venus and are extending the scope of their surface studies. This provides an excellent complementary fit with U.S. investigations of the atmosphere and remote radar studies of the surface. The data expected from our Pioneer Venus spacecraft, added to the Venera data, should significantly advance our knowledge of Earth's closest planetary neighbor." (Ibid., vol. 1, pt. 1, p. 519.)

[61] Hinners testimony, House Science and Technology Committee, 1978 NASA Authorization, 1977, vol. 1, pt. 1, p. 181.

[62] House International Relations Committee, Technology Transfer and Scientific Cooperation between the United States and Soviet Union, p. 118.

[63] Ibid.

[64] House Science and Technology Committee, Hearings, 1977 NASA Authorization, 1976, vol. 1, pt. 2, p. 502.

> They transmitted almost immediately very high quality negatives of the pictures which they took. We will have a meeting with them—the date is not set—to look at the information from the entries themselves. It takes longer than we would desire, frankly. We would like to get that as soon as possible. But their time scale for data reduction is extremely long. They just do not seem to have the basic computer capability to do rapid data reduction and get the engineering data analysis as fast as we do.

"It is frustrating," Hinners exclaimed. But, he assured the committee, "We have no reason to suspect that we won't get it, but it is not as timely as we would like." [65]

Whatever the degree of frustration, the fact remains that the Soviets did cooperate: They briefed U.S. space scientists on their Venera 9 and 10 missions, and in reciprocation NASA officials briefed their scientists on the preliminary results of the Viking landers on Mars. [66-69]

VENERA 11 AND 12; PIONEER 1 AND 2, 1978

Successful Venus missions

Another opportunity for cooperation came in 1978 with the opening of the Venus launch window. The Soviet Union and the United States had planned coinciding missions with their respective spacecraft, Venera 11 and 12, and Pioneer Venus 1 and 2.

Venera 11 and 12 were launched in September; both soft-landed on Venus in December. Pioneer Venus 1 and 2 were launched in May and August, respectively; both entered the Venusian atmosphere in December.

The American missions were judged a success, but the imaging systems on the Soviet probes failed, although they did return some data. [70]

U.S. hopes for cooperation

Dr. Hinners was hopeful that the Soviets would join in some form of cooperation at least in sharing scientific findings. He respected the Soviet planetary program, and in his public statements always spoke highly of it, referring to it once as "excellent." A strong advocate of space cooperation, he believed, in this case as in other areas of the space sciences that "information and data exchange, as well as coordination in the conduct of some experiments, can be mutually beneficial." [71] In 1976, Hinners had found out about the planned Soviet Venus probe set for 1978. He proposed a meeting in November 1977, as he said, "to coordinate our Venus program, and to look at the possibilities of an experiment exchange where we would fly experiments possibly on one of their spacecraft and vice versa; to try to do that very thing." [72]

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[65] Senate Aeronautical and Space Sciences Committee, Hearings, NASA Authorization for Fiscal Year 1977, 1976, pt. 2, p. 1130. For further explanations, particularly on the value of data from the Russians on Venera 9 and 10, see Hinners' testimony of November 1975 in, House Science and Technology Committee. Hearings, 1977 NASA Authorization, 1976, vol. 1, pt 1, p. 583. Hinners said that the Soviets "did a beautiful job. There is no doubt about it. The surface photographs are very good, and most of us did not at all expect to see what they have showed." He noted that he hoped to get the information before the end of the year so that "we can feed that into the Pioneer Venus." According to Hinners, "this meeting is time critical." His statement reflected a sense of urgency on the U.S. side, apparently not quite appreciated by the Soviets for technical reasons or those which they alone could answer for.

[66-69] Statement of Frutkin, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, pt. 2, p. 815.

[70] Sheldon, United States and Soviet Progress in Space, 1980, p. 73.

[71] House Science and Technology Committee, Hearings, 1979 NASA Authorization, 1978, vol. 1, pt. 2, p. 1430.

But the Soviets, always reluctant to discuss their future programs, delayed momentarily.[73] And while NASA officials were "somewhat frustrated," in Hinners' words, with Soviet resistance to the many American proposals to set up cooperative programs in the planetary area, meetings were eventually to be held and a cooperative program agreed upon.

Agreement on cooperation in Venus missions

Informal discussions took place initially in Moscow during November 14-17, 1977, to consider ways to improve planetary cooperation. Reporting on this meeting to the Congress on February 2, 1978, Dr. Hinners expanded on the following three areas needing improvement:

> No. 1 was the discussion of future plans. It is imperative that we understand what their objectives are. As an example, in terms of the 1983 Venus opportunity, where we may propose the imaging radar, we do know that the Soviets are working on a joint mission with the French to have a balloon in the Venus atmosphere that is complementary, but we had not heard about it directly. We heard about that initially through newspapers and third parties. It's essential for us on a bilateral basis to be privy to some of their thinking. Not that we'd pin them down to it, but so that we understand in what direction we are both heading and so that we avoid unnecessary duplication of activity on either side.
>
> A second step we would like to see is what we can do on joint planning. This is cooperative but not with hands on each other's spacecraft. Isn't there a way we can phase the arrival time of our individual missions to take maximum advantage of the simultaneous collection of information? I believe that will occur.
>
> The third item which I think will occur after we make progress on the first two, would be looking at the potential of joint experiments with us putting a U.S. experiment on a Soviet spacecraft and vice versa. In life science, it has worked very well. We have put experiments on their Kosmos series and the biological series. I am anticipating that we will have a meeting this April to followup and discuss in a formal working group session, primarily the Venus exploration——[74]

The meeting of the United States/U.S.S.R. Working Group on Near Earth Space, the Moon and the Planets did not take place in April as proposed but rather in June at Innsbruck, Austria. The group discussed the Venus 1978 missions, possible Venus 1983-84 missions, and important future lunar and planetary science objectives. Both sides exchanged information on the Venus 1978 missions and agreed to exchange further data obtained as they proceeded. The purpose: To enhance the scientific value of the missions for both sides.[75] A protocol was signed to this effect.

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[72] Ibid., vol. 1, pt. 1, p. 60.

[73] Ibid., p. 33.

[74] House Science and Technology Committee, Hearings, 1979 NASA Authorization, vol. 1, pt. 2, p. 1574. In testimony on Mar. 8, 1978, Terrell explained U.S. expectations with respect to cooperation in planetary probes. When asked if NASA was planning its planetary explorations in conjunction with the Soviet Union, he responded:

"No. We feel a complete and earlier exchange of information about the two sides' planetary programs would give each side an opportunity to plan its program in light of what the other side tended to do to achieve some degree of complementarity, if you will, between the two programs. Now we don't believe that we have had that kind of exchange. That was the point of the report I gave to you, that we want to get together with the Soviets and see what possibilities there are for getting a little bit earlier information, a little bit more complete information.

"We will do no joint planning at this stage. I think we are some distance from joint planning. Now we are interested in doing our individual national planning on the basis of a fuller understanding of what the other side may be intending to do. This could, of course, lead in the future to possibilities for joint planning, but that is not what is intended at this time." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, pt. 3, p. 936.)

Thus Dr. Hinners could tell the Congress on September 26, 1978, when Venera 11 and 12 and Pioneer Venus 1 and 2 were speeding toward Venus: "We do therefore have a coordinated view of the Venus missions going on now. . . . we will be exchanging scientific data from both of our missions and we are looking toward cooperative data analysis and possible experiments on the missions (SL76-2170)." [76]

Planetary cooperation on stream

Apparently, in-flight cooperation during the Venus 1978 missions was satisfactory; perhaps not so extensive as some space officials had hoped, but still useful nonetheless.[77] Exchanges of information did take place, for example, to help American scientists establish their trajectory patterns.[78] Also, the spacecraft of both sides—and there were a total of 10 involved, 2 landers, 5 atmospheric probes, two flyby vehicles and an orbiter—made simultaneous measurements of the solar winds, or atomic particles streaming from the Sun, for later comparisons of its characteristics at different points in interplanetary space.[79]

More extensive exchanges of information were to take place in the meetings of the United States/U.S.S.R. Working Group on Near Earth Space, the Moon and the Planets during 1979 and 1980. By all published accounts of NASA officials, the Soviets were forthcoming in exchanging information, and on a continuing basis. Moreover, they discussed plans for a possible U.S. Venus Orbiting Imaging Radar (VOIR) mission and a potential Soviet-French Venus probe with deployable balloon, scheduled for 1983 and 1984 respectively. The purpose was to explore ways of making future Venus missions more complementary and effective.[80]

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[75] Highlights of 1978 NASA Activities, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, pt. 2, p. 852.

[76] House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1978, vol. 1, pt. 1, pp. 357-358.

[77] Some of the skepticism was apparent in remarks by unnamed U.S. scientists at the time of the mission. Western scientists complained about the quality of data from Soviet missions. The results from Soviet probes were often released late and without adequate explanation as to how the data was obtained. "I've never seen any Soviet figures I could believe," said one U.S. scientist. Another U.S. scientist attributed the problem chiefly to the Soviet system itself that made an ongoing cooperative relationship among scientists and researchers difficult. (Waldrop, Mitch. U.S., U.S.S.R. Probes Begin Study of Venus. Chemical & Engineering News, vol. 56, Dec. 4, 1978: 20.)

[78] See the comments by Lawrence Colin of NASA's Ames Research Center. He was the Pioneer Venus project scientist, and Ames the control center for the mission. "We have set up what we hope will be a very fruitful cooperative scheme with the Russians," he said. Part of the cooperative planning involved using U.S. orbiter experiments in conjunction with the Soviet spacecraft when the latter arrived at Venus. "We hope . . . when their probes enter, to turn on our associated orbiter experiments and be able to take complementary data . . . when their probes and flybys are going by," Colin said. "Obviously, our probes should be long gone by then so it's up to our orbiter to provide correlative data." (O'Lone, Richard G. U.S., Soviets Cooperate in Exploration of Venus. Aviation Week & Space Technology, vol. 109, Dec. 4, 1978:23-24.)

[79] Large, Arlen J. Venus Data Could Lead to a Rethinking of Theories on Foundation of the Planets. The Wall Street Journal, Dec. 11, 1978, p. 14.

[80] Highlights of 1979 Activities: Year of the Planets. In, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980 pt. 2, p. 818; statement by Frosch, House Science and Technology Committee, Hearings, 1980, NASA Authorization, 1979, vol. 1, pt. 2, pp. 540-541. For a commentary on the meetings of the working group and plans for further cooperation in Venus missions, see, the response to questions by NASA's Office of Space Science, in House Science and Technology Committee, Hearings, 1980

Continued

Further discussions on cooperation in exploring Venus continued into 1980, notwithstanding the breakdown in political relations brought on by the Soviet invasion of Afghanistan. The Soviet Union plans to land robot spacecraft on Venus in the next 5 years, using new U.S. radar maps of the cloud-enveloping planet to select the landing sites. Mr. Harold Masursky, planetary scientist at the U.S. Geological Survey, conferred with scientists of the Vernadsky Geochemical Institute in Moscow, advising them on landing areas of potentially the highest scientific interest based on the latest U.S. maps of Venus. Masursky, who came away with many details of the Soviet mission, explained the benefits of this form of cooperation, stressing the element of complementarity:

> We do orbiters at Venus and they do landers, and so cooperation is mutually beneficial. We know roughly what the surface looks like from our radar surveys, and they will land there and tell us what the chemistry of that surface is like.[81]

OTHER AREAS OF PLANETARY COOPERATION

Exchange of lunar samples

While Venus took center stage in Soviet-American planetary cooperation, there were, nonetheless, other areas, important also, that attracted attention. One such area was the exchange of lunar samples that under the terms of a special agreement provided each side with unique materials for scientific study, the yield of the U.S. Apollo and Soviet Luna programs.

Studies of the Soviet Luna 16 and Luna 20 samples continued into the period under review, providing information about areas of the Moon not visited by Apollo. An agreement was reached between NASA and the Soviet Academy of Sciences in August 1976 to include in the exchange several samples of the lunar soil cores obtained by Luna 24 from Mare Crisium, also an area of the Moon not visited by Apollo. Samples were exchanged in December 1976 and March 1977.[82] The last exchange took place in March 1979.[83] Luna 24 had been the most successful Soviet automatic lunar

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NASA Authorization, 1979, vol. 1, pt. 2, p. 678. The stage of Soviet-American cooperation in exploring Venus at this point was explained by Dr. Hinners in hearings before the House Science and Technology Committee on Feb. 14, 1979. Hinners referred to the "excellent program" the Soviets have for planetary exploration, particularly of Venus. He noted the flow of information coming both ways on the 1978 Venus missions. "The next step which might consist of flying experiments on each other's space craft," he continued, "is the one to pursue. They are, jointly with the French, planning a 1983 balloon mission, using the Soviet entry vehicle, they will drop off a French-supplied balloon which would float in the atmosphere of Venus and make some investigations. When we talked about VOIR, we discussed the possibility of [illegible] be doing some joint experiments. We have to reexamine how much sense that makes. We are at that level. We are not yet at the level of a joint program in the same sense that we run productively with the European Space Agency. To do that kind of a program requires an extremely free interchange of scientists and ideas and a look into the engineering capabilities much more than we have seen any indication that the Soviets are willing to show." (House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1979, vol. 1, pt. 3, pp. 1525–1526.) VOIR has since been indefinitely postponed, and the 1984 Soviet Venus mission has been restructured to include Halley intercept, "bumping" the balloon.

[81] Wilford, John Noble. Soviet Union Plans 4 Missions to Venus. The New York Times, Nov. 23, 1980, p. 18.

[82] Statement of Hinners, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, 1977, pt. 2, p. 1214, and House Science and Technology Committee, Hearings, 1979 NASA Authorization, 1978, vol. 1, pt. 2, p. 1438.

[83] Response to questions addressed to Dr. Thomas A. Mutch, NASA Associate Administrator, in U.S. Congress. House Committee on Science and Technology. 1981 NASA Authorization. Hearings before the Subcommittee on Space Science and Applications. 96th Cong., 2d sess. Washington, U.S. Government Printing Office, 1980, vol. 4, p. 1461.

lander, having succeeded in drilling to a depth of 2 meters and in returning this sample core to Earth.[84]

Aside from the political value in furthering the principle of Soviet-American space cooperation, this exchange of lunar samples provided both sides with invaluable materials for scientific study on the origin of the Moon, its geology and raw materials. In brief, the exchange expanded the range of human knowledge about the Moon and the planetary system.[85]

Miscellany of planetary cooperation

Less significant was the miscellany of planetary cooperative efforts either contemplated, proposed, requested or attempted. The following list suggests the range of such efforts:

Dr. Fletcher, February 1977: "When it was believed that the lunar orbit of Luna 15 might pose problems for the Apollo 11 mission, NASA requested and received from the Soviet Union the coordinates of the Luna 15 orbit." [86]

Aviation Week & Space Technology, March 13, 1978: "In addition to this cooperative planetary program [that is, with respect to Venus], NASA and Soviet officials are discussing ways of cooperating more fully to prevent duplication of each country's planetary programs. The Soviets recently have requested U.S. lunar maps to aid in new Soviet mission targeting." [87]

On the eve of the COSPAR meeting in Innsbruck, Austria during June 1978, American space officials intended to confer with the Soviet delegation on a possible joint mission using the Soviet lunar polar orbiter. The Soviet lunar spacecraft was expected to fly no earlier than 1981. The United States hoped to place instruments on the craft that had been on Apollo 15, 16, and 17 to measure the radioactivity in the lunar crust and identify mineral distribution around that portion of the Moon being explored. These instruments, since refined, would be expected to perform the same function. About 20 percent of the Moon had been mapped by the three Apollo missions. A joint Soviet-American mission in lunar polar orbit would map the remaining 80 percent. Most of the expense would be borne by the Soviets; only the scientific instruments would be provided by the United States. NASA had failed to start its own lunar polar orbiter mission for want of funds and approval by the President.[88]

Soviet and American space officials have a procedure for requesting radio silence of satellites during a designated space flight to prevent loss of transmission. When Pioneer 11 was flying toward Saturn's moon, Titan, in September 1979, NASA asked the Soviets to keep three of their satellites in radio silence during the 4 hours on September 1 and 2 when Pioneer would be transmitting. The Soviets obliged and silenced Kosmos 1024, 1109. and 1122 during the crucial hours on those dates. Soviet broadcasting was resumed on September 4 because no further request for silence came from NASA. But NASA had erred; officials had failed to notify the Soviets of the flight's continuation, with the result that important data was partially lost and the remainder garbled because of accidental interference. According to a NASA explanation reported in the press:

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[84] Sheldon, United States and Soviet Progress in Space, 1980, p. 59.

[85] For reports and commentaries on the value of these exchanges, see, statement of Hinners, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 1, p. 392; for comments on the importance of the Apollo and Luna programs in providing "a rich source of lunar raw materials inventory data," see, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, 1977, pt. 3, p. 1516.

[86] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, pt. 2, p. 799.

[87] Aviation Week & Space Technology, vol. 108, Mar. 13, 1978:77.

[88] O'Toole, Thomas. U.S. Seeks Role in Soviet Moon Flight. The Washington Post, May 29, 1978, p. A2.

> The Soviets have been highly cooperative in avoiding such interference at critical times and ceased communication with three of their satellites, including the one in question, during requested periods on Saturday and Sunday. NASA officials indicate that they have no doubt that the Soviets would have avoided the conflict on Monday, if they had been asked. However, the impact of the potential interference was not recognized in time to make an additional request to the Soviets.[89]

Presumably in January 1979, the Committee on Planetary and Lunar Exploration of the National Research Council, a constituent part of the National Academy of Sciences, published a report entitled, "Strategy for Exploration of the Inner Planets (SEIP)." The purpose of the report was to help govern the planning of planetary missions through 1987. It urged particularly that formal negotiations be undertaken with the Soviets to explore the possibility of coordinated lunar missions. In brief, the report rejected token Soviet cooperation and called for a full partnership in planetary exploration. Among the committee's recommendations were the following, as summarized in the source:

> Establishment of active, open working relationships between Soviet and American scientists.
>
> Mutual identification of important scientific goals.
>
> Early reciprocal communications between the United States and the Soviet Union on specific current and planned planetary scientific objectives.
>
> Establishment of concurrent commitments by both nations to achieve goals in selected areas of mutual interest utilizing the agreed-upon scientific objectives.
>
> Coordination of missions to a planet with full disclosure of mission planning and objectives in order to maximize the scientific contributions of both nations.
>
> Establishment of true cooperation between both nations through a reciprocal arrangement that would allow the incorporation of significant experiments by both parties on the same spacecraft.
>
> Timely communication and exchange of information both during and after completion of a mission.

The initial Soviet response to the SEIP report encouraged optimism among U.S. scientists. Tass issued a straightforward account of the recommendations, including a discussion of possible benefits.[90]

A MEASURE OF OPTIMISM

From the American perspective, these SEIP recommendations do not appear to have been excessive; but in reality they were overoptimistic, given the stress in political relations by the end of the 1970's. Nonetheless, cooperation in planetary areas has proved to be fruitful and moderately satisfying for both sides. And even this small measure of success deserves emphasis, particularly in a relationship that, despite periods of tension and aggravation, has in fact come a long way.

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[89] Wilford, John Noble. NASA's Failure to Alert Russians Caused Loss of Saturn Moon Data. The New York Times, Sept. 5, 1979, pp. A21 and A22; The Washington Post, Sept. 5, 1979, p. A10; and O'Toole, Thomas. "Lost" Transmission from Saturn May Be in the Computer. The Washington Post, Sept. 7, 1979, p. A6.

[90] Covault, Craig. U.S./Soviet Venus, Moon Flights Urged. Aviation Week & Space Technology, vol. 110, Jan. 15, 1979: 17-20.

U.S. PARTICIPATION IN SOVIET BIOSATELLITE EXPERIMENTS

IMPORTANCE OF BIOSATELLITE COOPERATION

Supporters of space cooperation have had cause for satisfaction in the series of U.S. biological experiments carried aboard Soviet biological satellites under a cooperative arrangement. For the United States, participation was especially important because it did not have a biosatellite program and therefore at a minimum cost could benefit from the Soviet life sciences program.

Life science experiments had been conducted aboard ASTP, but the Apollo program closed out the United States from any further biomedical experiments.[91] Not until the development of the Spacelab/Shuttle space systems would the United States have a full capability for independent life science experiments in space.[92] Thus Soviet cooperation provided the United States, as one space writer put it, with a "cut-rate way" to bolster its store of knowledge in light of a weak space biological program and a long hiatus between manned space missions.[93]

KOSMOS 782, 1975

Soviet invitation and experiments

At the fifth meeting of the Joint United States/U.S.S.R. Working Group on Space Biology and Medicine in Moscow during October 26–November 3, 1974, the Soviet Union invited the United States to fly biological experiments on their third biosatellite, Kosmos 782.[94] (Previous Soviet biosatellites were Kosmos 110 flown in 1966 and Kosmos 605 in 1973.) On November 25, 1975, Kosmos 782 was launched for a flight that lasted 19.5 days. The spacecraft carried several biological experiments: Those by the Soviet Union, their Interkosmos associates, France, and the United States. This flight marked the first time that the Soviet Union carried American experiments aboard one of its spacecraft.[95]

Briefly, the experiments centered around the addition of a centrifuge never before carried aboard a spacecraft. This device made it possible to conduct some experiments in the state of weightlessness while others were in simulated Earth gravity. Besides its own four experiments in self-contained packages, the United States was invited to particpate in several Soviet experiments. One such experiment, for example, dealt with a stress reaction of animals (in this case, white rats) during space flight.[96]

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[91] For a discussion of ASTP life sciences experiments, see, testimony of Yardley, Senate Aeronautical and Space Sciences Committee, hearings, NASA Authorization for Fiscal Year 1976 and the Transitional Period, 1975, pt. 1, pp. 199–200.

[92] Statement of Hinners, House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1979, vol. 1, pt. 3, p. 1398.

[93] O'Lone, Richard G. U.S., Soviets to Discuss More Biosat Missions. Aviation Week & Space Technology, vol. 107, Sept. 26, 1977:95. In commenting about the Kosmos 782 and 936 missions, O'Lone wrote that the Russians "did not charge the U.S. a nickel for the Cosmos missions, and total U.S. costs for the effort will amount to about $450,000. This is a tiny fraction of what it would have cost the United States to mount such a mission from scratch." O'Lone's source was Harold P. Klein, Director of Life Sciences at NASA's Ames Research Center in Mt. View, Calif.

[94] Testimony of Yardley, Senate Aeronautical and Space Sciences Committee, Hearings, NASA Authorization for Fiscal Year 1976 and the Transitional Period, 1975, pt. 1, p. 200.

[95] House International Relations Committee, Technology Transfer and Scientific Cooperation between United States and Soviet Union, pp. 116–117.

Judgments on cooperation

The judgments on Soviet-American cooperation in the Kosmos 782 mission were favorable. Perhaps, Frutkin best summed up NASA's official views when he stated upon completion of the mission and the return of the experimental materials, "We can say that that has been a most successful relationship." [97]

The experiments were "quite modest," as Dr. David L. Winter, NASA Director for Life Science, said; all were self-contained; no technology was transferred.[98] The Soviets handled the experiments to the full satisfaction of the U.S. scientists. American scientists were not allowed at either the launch or recovery sites; but their presence, not being necessary, was not requested.[99]

Thirty-six hours after touchdown, the Russians returned the American experiments to the U.S. scientists waiting in Moscow. Mr. Larry P. Chambers, U.S. Program Director for Kosmos 782, was surprised at Soviet efficiency and presumably good faith in managing the U.S. experiments. "They bent over backwards to help us," he exclaimed.[1]

Though the experiments were limited, still the information derived from postflight analyses was, "extremely useful," as Kenneth A. Souza of NASA's Ames Research Center wrote in a commentary on the Kosmos 782 and 936 missions.[2] The Soviets had promised a written report within a year from the mission's completion. None was forthcoming (though none was formally required), but they did present some results verbally. Many of the verbal presentations were "quite good," according to Winter.[3]

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[96] Ibid. For a commentary on the experiments, see, statement of Dr. Joseph Sharp, House Science and Technology Committee, Hearings, 1976 NASA Authorization, 1975, vol. 2, pt. 1, pp. 616–617. See also, statement of Hinners, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, 1977, pt. 2, pp. 1227–1228.

[97] House Science and Technology Committee, Hearings, 1977 NASA Authorization, 1976, vol. 1, pt. 2, pp. 646–647. Frutkin continued: "Since we do not have biological programs in being, or in early prospect, this represents an opportunity for us that we would not otherwise have." For further comments on the technical aspects of the Kosmos 782 mission, see p. 662.

[98] Testimony of Winter, House Science and Technology Committee, Hearings, 1977 NASA Authorization, 1975, vol. 1, pt. 1, pp. 670–671.

[99] Ibid. Winter explained that "we will not have anyone at the launch site, nor at the recovery site." "Quite frankly, we did not even request to go. This particular endeavor came about at their invitation," he noted. Winters also made it clear that this experiment, other than instrumentation, was at no cost to the United States. "We are getting a free ride, quite frankly," he said, "and the cost is very modest."

[1] House International Relations Committee, Technology Transfer and Scientific Cooperation between United States and Soviet Union, p. 117.

[2] Souza, Kenneth A. The Joint United States-U.S.S.R. Biological Satellite Program. Bio-Science, vol. 29, March 1979:166. This article is a highly technical commentary on the experiments. Still his conclusion suggests, even to the layman, the value of the missions: "We now know that spaceflight factors, principally weightlessness, have a measurable effect on the erythropoietic and musculo-skeletal systems and on the carbohydrate and lipidmetabolism of rats. We learned that artificial gravity produced by centrifugation has the potential for counteracting some of the detrimental effects of spaceflight. Observations of rat retinal tissue during both flights suggested that cosmic radiation may be a hazard to man during prolonged stays in space. We also learned that spaceflight had little (if any) effect on the growth and development of a variety of biological tissues, including the carrot * * *, the minnow * * *, and the fruit fly * * *, although additional studies of the activity and behavior of adult Drosophila [fruit fly] during spaceflight are needed."

[3] House International Relations Committee, Technology Transfer and Scientific Cooperation between United States and Soviet Union, p. 117.

In April and October 1976, American and Soviet scientists met to review the findings of Kosmos 782. Perhaps the best evidence of satisfaction on both sides was the conclusion of a tentative agreement to fly five U.S. experiments as candidates for a mission planned in 1977.[4]

Kosmos 782 was thus a success, both scientifically and politically. For the purpose of demonstrating the Soviet attitude toward space cooperation the mission was especially meaningful because the Soviets were playing the role of grantor, the possessor of all negotiating leverage, and the United States, the role of recipient or supplicant, the weakest position in any negotiations. Yet despite their advantage the Soviets appear to have played it straight, and fair.[5]

KOSMOS 936, 1977

Planning, flight, and experiments

The momentum, gathering in the Kosmos 782 project, was carried into the Kosmos 936 mission, apparently producing generally the same satisfactory results.[6] In September 1976, the Joint United States/U.S.S.R. Working Group on Space Biology and Medicine met in Yerevan, U.S.S.R. and agreed upon and began detailed planning for five U.S. biological experiments (actually seven were flown) to be flown on Kosmos 936 biosatellite scheduled for launching in late 1977.[7]

On August 3, 1977, Kosmos 936 was launched, carrying biological samples and scientific instrumentation belonging to the Soviet Union, Czechoslovakia, France, and the United States. Specialists from Interkosmos, France, and the United States were scheduled to take part in the research and processing of the experimental biological materials.[8] After a flight of 18.5 days, Kosmos 936 was recovered on August 22.

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[4] Ibid., and statement of Hinners, House Science and Technology Committee Hearings, 1978 NASA Authorization, 1976, vol. 1, pt. 1, p. 10.

[5] The extent to which the Soviets had determined to cooperate in the life sciences was evident in the testimony of Dr. Joseph Sharp taken at the Ames Research Center in February 1975. Sharp explained the Kosmos project, noting the nature of the planned experiments, purposes, and cost. Sharp was asked: "Are we learning anything from them or are they just picking our brains?" To which Sharp replied: "Well, we received from them, at the meeting in October, about a 450-page document in Russian that described in the greatest detail that we have ever seen of any of their experiments, the Cosmos 605 via satellite experiments. They went through every one of the experiments they had described. What their problems were; what their findings were." Sharp continued, "Well, first of all, this was an unmanned satellite so we were dealing strictly with animal or plant material. There were indeed some surprises in that data." Asked if the Soviets were indeed sharing, Sharp replied, "I think, in fact, they are." And he explained further: "Now, in addition, at that meeting they exchanged * * *. There was an honest exchange, I believe, on the medical findings of the cosmonauts and astronauts postflight, the followup studies and the physicals. Both theirs and ours. And an agreement was made about how the physicals would be conducted. How the tests would be done even to the point of how you would determine the amount of electrolytes in urine or blood so both countries were using the same measurements. So we had a good idea what their numbers meant." Sharp concluded: "In fact, we had suggested to them that they run the identical tests in their laboratories that we will run here. Admittedly, this is tentative. A very tentative step into this corroborative role. We don't know how it will come out. It seems to take forever right now." (House Science and Technology Committee, Hearings, 1976 NASA Authorization, 1975, vol. 2, pt. 1, pp. 617–618.)

[6] For an explanation of the procedures for setting up these joint experiments, see response to questions for the record in Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, pt. 1, p. 474.

[7] Statement of Hinners, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, pt. 2, p. 1228.

[8] Moscow Tass in English, 1904, Aug. 3, 1977, in FBIS Daily Report: Soviet Union, vol. 3, Aug. 4, 1977:U1.

According to Dr. Hinners, the U.S. experiments included the use of laboratory rats to investigate the effects of weightlessness and 1-G centrifugation on red blood cell life span, liver enzyme activity, bone growth and muscle changes. Also included were high energy particle dosimetry and electron microscopic examination of zero-gravity effects on the genetics and aging of fruit flies. After recovery of Kosmos 936, the biological samples and dosimeters were returned to the United States in September for study by American investigators during the following year. Plans were set for an initial exchange of results in March 1978, to be followed by a Soviet symposium on Kosmos 936 in the fall.[9]

Appraisals, meetings, and value of U.S. participation

Kosmos 936 proved to be another success for space cooperation. "We continue to enjoy substantial international cooperation in the space life sciences," reported Dr. Hinners to the Congress in September 1976.[10] And in a further report in February 1978, he stated:

> We continue to have successful cooperation with the Soviets in the biological sciences, flying experiments on their unmanned Kosmos series of biological satellites. We anticipate flying experiments on subsequent flights, in 1981 and 1982, with the Soviets.
>
> The whole area of Soviet cooperation is getting increased attention now, both on account of their long-duration manned activity in space, which is in progress, and because we are looking at the potential for increased cooperation with the Soviets.[11]

Kenneth A. Souza of NASA's Ames Research Center and manager of the U.S. experiments said that the Soviets were "extremely cooperative in all dealings" and answered all questions "as best they could." He said further that the quality of engineering displayed in the mission hardware was excellent and that the Soviet technicians processing the U.S. experiments were "top notch."[12]

The Soviets were no less approving in their commentary. Tass correspondent Nikolay Zheleznov exclaimed that the biosatellites of the Kosmos series "reach the orbits of international cooperation" and that Kosmos 936 was "a striking illustration of this." With an eye on space politics Zheleznov concluded that the "new orbit blazed in world science" by Kosmos 936 was the "best illustration" of how the process of detente was "really filled with new vivid facts of widening cooperation between scientists of various countries in major branches of science and technology." Nonetheless, his account contained many details in layman's language on the scientific and technical aspects of the mission.[12A]

The rhetoric on both sides seemed to be matched by performance in the exchange of information at subsequent meetings. During November 1977, the eighth meeting of the Joint United States/U.S.S.R. Working Group on Space Biology and Medicine took place at Wallops Island, Va. and Bethesda, Md. The conferees discussed the preliminary results of the Kosmos 936 experiment as well as proposals for future biosatellite missions along with the medical results of manned space flight. The Soviets invited the United States to participate in their biosatellite flights in 1980 and 1981.[13]

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[9] Statement of Hinners, House Science and Technology Committee, Hearings, 1979 NASA Authorization, 1977, vol. 1, pt. 1, p. 99.

[10] House Science and Technology Committee, Hearings, 1978 NASA Authorization, 1976, vol. 1, pt 1, p. 10.

[11] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, pt. 1, pp. 288–289.

[12] O'Lone, U.S., Soviets to Discuss More Biosat Missions, p. 95.

[12A] Moscow Tass in English, 2020 GMT, Aug. 3, 1977, pp. U1–U2, in FBIS Daily Report: Soviet Union, vol. 3, Aug. 4, 1977, pp. U1–U2.

For NASA's Life Sciences Division the series of joint meetings conducted over the past 7 years with their Soviet counterparts were, in Dr. Hinners' words, "very productive." In a report to Congress in September 1978, he stated that the final report on the U.S. experiments flown abroad Kosmos 936 were completed and forwarded to Moscow. This report was to be presented in Moscow during the Kosmos 936 International Symposium scheduled for October 19–21, 1978. Hinners also noted that 14 U.S. proposals for scientific experiments were submitted to the Soviets in June 1978 to be flown aboard Kosmos 1980. The Soviets were expected to acknowledge selection of some or all of these experiments during the 9th meeting of the joint work group in Leningrad on October 10–18, 1978. At that time detailed negotiations would determine the extent of U.S. participation in Kosmos 1980.[14]

Judging from commentaries by NASA officials there seems little doubt that U.S. participation in the Kosmos project through 936 was important and useful. When asked to respond to the question, "How important are these flight opportunities in our Life Sciencies Program?" NASA replied simply:

> The Soviet biological flights are important in two ways: First, they provide an opportunity to do research that could not otherwise be done until the Life Sciences Spacelab missions fly in the future; and second, they give us the opportunity to become familiar with the special problems associated with animal maintenance in flight.[15]

KOSMOS 1129, 1979; AND THE FUTURE

Continuing interest in Kosmos biosatellite

U.S. participation in the Kosmos biosatellite project continued into 1979 with the flight of Kosmos 1129 and into the future with at least proposals for specific cooperative programs for 1980 and 1981. In addition, cooperation in the life sciences took place in ground-based studies relating to weightlessness in long-duration manned flights.[16] But the events in Afghanistan brought about the suspension of what seemed to be a durable regime of cooperation in the life sciences as indeed in planetary exploration.

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[13] NASA News. Release No. 78–10. Summaries of Two U.S.-Soviet Meetings Issued in, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, pt. 1, pp. 118–128. For a technical explanation of achievements at these meetings, see the statement of Dr. Hinners in these hearings on pp. 406–407.

[14] House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1978, vol. 1, pt. 1, p. 326.

[15] NASA response to questions, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, pt. 1, p. 474. To this general point could be added the specific values cited by Souza quoted above and also explained in O'Lone's commentary on the biosatellite missions in Aviation Week & Space Technology, also cited above.

The following statement by Dr. Hinners on Kosmos 936 suggests even to the uninstructed layman the value of such experiments for future U.S. manned spaceflights:

"The Soviet Union continues to cooperate with us in the life science area. We had a successful joint mission with the Soviets, flying on their Kosmos satellite last year, and found out some very interesting and strange new things.

"We have been aware of the calcium loss in the astronauts' bones. In the near-term it has not been a problem; in the long-term it might be, and that is why we are studying this area.

"What came out of the Kosmos biological experiments is that the amount of calcium, per se, may not be the only indicator of a change in activity; indications are that you may not have to lose a lot of calcium before bone strength changes. What was found is that the bone strength degrades very rapidly. Bones become very fragile with a small amount of calcium loss. There is a lot to be gained in studying this changing physiology.

"I am a little chagrined at the attitude I find in the life sciences area within and outside of NASA as to whether we do or don't know what is going on with man in space."

Hinners proceeded to explain the linkage between the Kosmos biological experiments to long-term U.S. manned spaceflights and the physiological problems involved therein. (Statement of Hinners, House Science and Technology Committee, Hearings, 1979 NASA Authorization, 1978, vol. 1, pt. 2, p. 1560.)

In September 1979, the United States placed 14 experiments, along with those from the Soviet Union, Czechoslovakia, and France, aboard the Soviet biosatellite Kosmos 1129 for a flight lasting 19 days. All experiments were designed to test the effects of weightlessness on physiological processes. U.S. participation included experiments with biological specimens (rats, quail eggs), space radiation, dosimetry, and postflight specimen preparation in Moscow. At the end of 1979, U.S. scientists were still analyzing the flight material with the expectation of presenting their results at a joint meeting in 1980.[17]

And the future

Continuing Soviet and American satisfaction with cooperation in the Kosmos biosatellite project was evident with the Soviet invitation to the United States in October 1978 to propose experiments to be carried aboard their next generation biosatellite scheduled for launching in 1982. This mission would be using primates. In 1979, NASA undertook advance planning for the project.[18] NASA eventually submitted six proposals, two of which were accepted in principle by the Soviets in October 1979; the others remained under consideration.[19]

In 1977, the United States, in reciprocation for Soviet largesse in allowing U.S. participation in their biosatellite project, invited Soviet proposals for experiments to be flown on a life science Spacelab mission aboard the Space Shuttle sometime in 1984-85. As of October 19, 1979, the Soviets had submitted no formal proposals, though discussions on potential Soviet proposals were held between NASA and Soviet life sciences specialists.[20]

What the future holds for Soviet-American cooperation in the life science area can only be a matter of conjecture, given the downturn in political relations. Having succeeded in launching the Shuttle, the United States will be able to accumulate greater knowledge in the life sciences on its own. As Dr. Lovelace said in 1980:

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[16] The first joint United States/U.S.S.R. ground-based study to investigate physiological changes in humans resulting from simulated weightlessness was conducted during 1979. In May, two NASA scientists participated as observers in an experiment at the Institute of Biomedical Problems in Moscow. In the second phase of the study, two Soviet scientists, both M.D.'s, observed NASA's experiments at Ames Research Center. (Highlights of 1979 Activities, NASA News, Dec. 27, 1979, in Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 2, p. 818.)

Frutkin gave the following appraisal of cooperation in this area: "If I may say, there has been a rather extraordinary openness of exchange in this particular area, the physiological results of space flight." This judgment was preceded by the insertion of a NASA statement recording specific instances of Soviet cooperation, for example, the Soviet report on the biomedical results from their 96-day space mission aboard Salyut 6. (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 3, p. 1650.)

[17] Highlights of 1979 Activities, NASA News, Dec. 27, 1979, in Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 2, p. 818. Further details on the results of Kosmos 1129 will be discussed in volume II of this report.

[18] Response to question, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, 1979, pt. 2., p. 934.

[19] Response to question, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, pt. 2, p. 1236.

[20] Statement of Dr. Thomas A. Mutch, Associate Administrator for Space Science, NASA, House Science and Technology Committee, Hearings, 1981 NASA Authorization, 1979, vol. 1, p. 240. See also, response to question, ibid., p. 342.

> It is clear that we have not been accumulating data on manned space flights since the Apollo/Skylab and ASTP space projects. . . . Once the space shuttle becomes operational, it will allow us to come back up on the learning curve of the manned aspects of space life sciences.[21]

Yet, the United States remains committed, at least formally, to participating in the Soviet biosatellite project, notably the 1981 flight. As NASA responded to a congressional inquiry on this point:

> We believe that this joint activity is of specific scientific interest to the United States and consistent with current U.S. policy. U.S. preparations leading up to the 1981 Cosmos flight will, of course, be subject to U.S. Government review.[22]

Meanwhile, cooperation in the life sciences is, apparently, at a standstill, or rather in a state of suspension. As Dr. Frosch explained on February 6, 1980, with respect to meetings of the joint United States/U.S.S.R. scientific working groups, "we are simply at a stage where we were in between activities." [23]

Yet, it is significant as an indication of the Soviet attitude toward space cooperation that in April 1980, a time of great stress in Soviet-American relations, a leading Soviet scientist could look back over a decade of Soviet-American cooperation with an approving glance. Writing in the Soviet foreign affairs weekly New Times, Dr. Nikolai Gurovsky, head of the Department of Space Biology and Medicine in the Soviet Ministry of Public Health, recalled:

> A fairly wide programme of joint research has been carried out over the past ten years with American scientists. It is co-ordinated by a Soviet-American working group on space biology and medicine. At first co-operation was confined to an exchange of information on the results of land and space experiments. Later on American experts took part in experiments on the Soviet biological Sputniks Cosmos 782, 936, 1129. Many land-based experiments follow identical programmes.

Gurovsky reminded his readers of the successful work done in space biology and medicine during the ASTP mission; noted that NASA officials have "on many occasions commented on the success and value of joint work" under the Interkosmos program; and then concluded with a statement of approval of space cooperation as "an important factor in international relations." [24]

Soviet Participation in Landsat

DEVELOPMENT AND APPLICATION OF LANDSAT TECHNOLOGY

Soviet participation in U.S. remote sensing systems, such as Landsat, did not equal the extent of cooperation experienced in the Kosmos biosatellite project. But Soviet cooperation in remote sensing, however small, was, nonetheless, important: For it reflected an aspect of the Soviet attitude toward bilateral space cooperation with the United States, and, accordingly, it is worthy of note.

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[21] House Committee on Science and Technology. Hearings, 1981 NASA Authorization, 1980, vol. 5, pp. 3113–3114.

[22] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 2, p. 1236.

[23] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 2, p. 1055.

[24] Gurovsky continued: "As he journeys into outer space man becomes ever more conscious of his links with the Earth. No wonder cosmonauts are often described as 'sons of the earth.' The farther the cosmonauts penetrate into outer space, the more keenly will earthmen be conscious of belonging, as it were, to one great family on a spaceship in the Universe." (Is There a Limit to Manned Space Flight? New Times (Moscow), No. 15, April 1980:15.)

It is not the purpose here to explain the technicalities of the Landsat system in any great detail, but merely to sketch out its essentials so as to make the Soviet cooperative effort comprehensible. A full explanation can be found in the Congressional Research Service report, World-Wide Space Activities.[25] Suffice it to say that the concept grew out of efforts first used in manned spaceflights to photograph Earth from space. New types of high altitude imagery with multispectral scanners were developed and tested using aircraft. This work led to the development of a new global data acquisitions system consisting of a multispectral scanner mounted on a satellite observation platform. This concept became known as Landsat.[26]

Landsat 1 was launched on July 23, 1972, followed by Landsat 2 on January 22, 1975 and Landsat 3 on March 5, 1978. Other Landsat satellites with improved capabilities are planned for the future. Also other systems were developed enlarging upon the Landsat concept and including Landsat in these systems, for example, LACIE, an acronym for Large Area Crop Inventory Experiment, and Agristars, meaning, Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing.[27]

Landsat is an Earth resources satellite with multidisciplinary application on a global scale.[28] It made possible the study of Earth resources with the application of space technology in such widely diverse areas as: The search for mineral deposits and oil fields; the study of forestry resources and the location of forest fires; identification as to location of diseases of trees and agricultural crops; the taking of crop census; the study of snow fall, water resources, fisheries; mapping; and many other similar practical enterprises to be carried on from space.[29]

One area where Landsat imagery proved to be most valuable has been in agriculture.[30] Briefly, Landsat has made it possible to survey global agricultural resources on a continuing and frequent basis efficiently, effectively, and economically—a factor of great importance to the Third World. It is not surprising, therefore, that interest in the program for surveys and management of natural resources and other surface features increased considerably during the 1970's so that in 1977 Frutkin could refer to this universal growth of interest as "remarkable." Frutkin supported his appraisal with evidence that some 130 countries had purchased Landsat data from the U.S. Data Center in South Dakota where it is collected and stored.[31]

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[25] See, Lani Hummel Raleigh, Specific International Applications Satellite Programs, in House Science and Technology Committee, World-Wide Space Activities, ch. 5, pp. 436–466.

[26] Ibid., p. 436.

[27] Ibid., p. 441. For an explanation of Agristars, see, House Science and Technology Committee, Hearings, 1981 NASA Authorization, 1980, vol. 4, p. 1623.

[28] Landsat 1 was originally known at the Earth Resources Technology Satellite (ERTS).

[29] Sheldon, United States and Soviet Progress in Space, 1980, pp. 54–55.

[30] For commentary on its value in agriculture, see, House Science and Technology Committee, World-Wide Space Activities, 1977, pp. 440–444.

[31] House Science and Technology Committee, Hearings, 1978 NASA Authorization, 1977, vol. 1, pt. 3, p. 71.

SOVIET PARTICIPATION IN LANDSAT SYSTEM

Soviet interest in Earth resources satellites

The Soviets were latecomers in the application of space to Earth resources, at least in the form of a Landsat-type program, and even then their system had limitations. Ordinarily, they collected Earth resources imagery from their manned spacecraft. And not until May 26, 1977 did they launch an Earth resources satellite. It transmitted data to "Priorda" ("Nature"), the Soviet Earth resources data processing center, and was recovered on June 8, 1977.[32]

Unlike Landsats which operate for years, returning data by radio, the Soviet Earth resources satellites, which are indistinguishable from military observation recoverable flights aside from the labeling, according to Sheldon, land with film after a 2-week staytime in space.[33] Delays in developing an Earth resources system and its limitations when developed seem to explain Soviet interest in participating in the U.S. Landsat program. The Soviets are experimenting with new systems in the Meteor 2 program, however.

Soviet-American agreement on remote sensing

The agreement of 1971 on Soviet-American space cooperation, formally endorsed at the May 1972 Summit Conference, established the basis for a subsequent specific agreement on remote sensing. Officials of NASA and the Soviet Academy of Sciences had undertaken discussions and reached agreement on a joint effort to identify vegetation, soils and land uses using ground truth and aerospace technology. (Dr. Fletcher explained the meaning of "ground truth": In this case it "is simply actual data, obtained from people walking around in their agricultural areas. This information helps us to calibrate our own estimates of Soviet wheat production in these areas.")[34] According to Dr. Don Paarlberg, Director of Agricultural Economics, Department of Agriculture, the proposed cooperative effort, approved in 1976, called for "exchange of ground truth and remotely sensed data for the United States and Soviet sites, independent analysis of data for both sites, and full exchange of research results." USDA was to cooperate with NASA in this program.[35]

Examination of NASA authorization hearings from fiscal year 1976 through fiscal year 1981, in which official commentary and reporting on Landsat and LACIE were extensive, suggests that the cooperative arrangement for remote sensing was both satisfying and successful. The Soviets did, indeed, cooperate. As Frutkin reported on February 25, 1977:

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[32] House Science and Technology Committee, World-Wide Space Activities, 1977, p. 453.

[33] Sheldon, United States and Soviet Progress in Space, 1980, pp. 54–55, and Sheldon, Soviet Space Activities in 1977, p. 75. In a survey of Soviet space activity at this time, Aviation Week reported: "In a new earth resources emphasis, the Soviets recently established a center devoted to analysis of such data obtained from space. The Soviets have used normal reconnaisance spacecraft, a new Meteor weather spacecraft design and the Salyut space station to provide earth resources data." (New Designs Spur Soviet Space Activity. Aviation Week & Space Technology, vol. 108, Mar. 13, 1978:77.)

[34] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, 1977, pt. 2, p. 772.

[35] For a complete explanation of the terms of the agreement, see statement of Paarlberg, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1977, pt. 2, p. 1407. For other commentary, see pp. 1403 and 1415.

> The joint project for remote sensing of crops and vegetation at analogous U.S. and U.S.S.R. test sites has produced for us an exchange of Soviet "ground truth." This has given us the basis for calibrating Landsat data of Soviet wheat areas, thus contributing usefully to LACIE, our Large Area Crop Inventory Experiment.[36]

Dr. Fletcher explained that, "This information helps us to calibrate our own estimates of Soviet wheat production in these areas," he said, elaborating on the point of exchange: "They gave us ground truth from the Kursk area of the area of the Soviet Union, and, in exchange we provided them with comparable information from an agricultural area in South Dakota." [37]

Official appraisal of Soviet cooperation in LACIE was also favorable, though the Soviet Union was not bound by any agreement in this project.[38] Nonetheless, the Soviets gave tacit support for LACIE. As Frutkin explained:

> The Soviet Union is engaged in a bilateral remote sensing program with NASA involving the exchange of "ground truth" from agricultural areas in the U.S. and U.S.S.R. This exchange is contributing to the verification of satellite data for wheat crop prediction and therefore represents tacit Soviet support for our Large Area Crop Inventory Experiment (LACIE).[39]

In another instance Frutkin extended the "broader significance" of the Soviet role in the LACIE project. He pointed out that the Soviets were "fully aware" of the project and "in cooperating with us in this way, they are in effect assisting us to pursue the LACIE program." [40]

ON THE VALUE OF REMOTE SENSING AND SOVIET COOPERATION

From the American perspective Soviet cooperation in remote sensing was valuable, particularly in carrying on the Landsat program and the more comprehensive LACIE program. The success of both programs and the techniques and procedures that were developed have enabled the United States, in the words of Dr. Anthony J. Calio, NASA's Associate Administrator for Space and Terrestrial Applications, "to forecast wheat production in foreign areas on a timely and objective basis." [41] The programs have also effectively served the needs of the Third World.[42] With respect to the Soviet

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[36] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, 1977, pt. 2, p. 815.

[37] Ibid., pp. 772-773.

[38] At field hearings at the Johnson Space Center in Houston, Tex., Rep. Larry Winn, Jr. (R-Kans.) noted in a discussion of LACIE Russia's role in the program: "Russia probably would not object to you taking pictures over them in this case because it could be helpful to them." Dr. Kraft responded: "The United States has a cooperative agreement with Russia to exchange agricultural data." Mr. Charlesworth elaborated: "But that cooperative agreement does not involve LACIE. It is a separate agreement that provides for the exchange of ground truth information between the two countries." To which Mr. Winn speculated: "Then, they need this to know where they are, apparently." (House Science and Technology Committee, Hearings, 1977 NASA Authorization, 1976, vol. 1, pt. 2, p. 808.)

[39] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, 1977, pt. 2, p. 1286.

[40] House Science and Technology Committee, Hearings, 1978 NASA Authorization, 1977, vol. 1, pt. 3, p. 95.

[41] House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1978, vol. 1, pt. 1, p. 149.

[42] Lani Hummel Raleigh, Analyst in Science and Technology, Congressional Research Service, wrote: "Because of its numerous advantages [and they are cited], Landsat technology has been

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Union, Calio cited as one of "the major technical accomplishments" of the programs the ability to achieve "acceptable accuracies" for wheat production in the U.S.S.R., though he cautioned, "the repeatability of these accuracies over a longer period of time has yet to be demonstrated."[43]

He gave the following comprehensive statement to the committee:

> Over the last several years, most of the research and development effort addressing agriculture application needs has been focused to support the Department of Agriculture (USDA) in the Large Area Crop Inventory Experiment (LACIE). The experiment, covering three crop-years, was completed this summer. On the whole, the project provided very fruitful results. LACIE met the "at harvest" accuracy goal of 90 percent for wheat production in the U.S. Southern Great Plains and did as well in the U.S.S.R. (Figure 5). We have previously given you the general results LACIE obtained for the U.S.S.R. We are now able to report that LACIE accurately diagnosed the spring wheat situation and predicted a serious production shortfall as early as August 1977. Chairman Brezhnev's shortfall announcement on November 4, 1977, confirmed the LACIE prediction, as did the U.S.S.R. production results published in early February 1978.[44]

Though the emphasis in this section has been on agriculture, Soviet-American agreements were reached in other areas of remote sensing. In February 1976, for example, Dr. Vincent E. McKelvey, Director of the U.S. Geological Survey, reported on USGS's participation with NASA in a cooperative agreement with the Soviet

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used successfully in many of the developing nations—to inventory water resources in Iran, to track the desert locust in the Sahara, to map largely unknown regions of Brazil, to inventory forest land in Thailand, to search for iron ore in Egypt, and to determine land use and land capability in Tanzania." Further examples were cited on page 451 ff, in House Science and Technology Committee, World-Wide Space Activities, 1977, p. 544.

For an extensive commentary on the uses of remote sensing in the Third World, see the letter and enclosure by Dr. Frosch to Secretary of State Vance on May 10, 1979, in House Science and Technology Committee, Hearings, 1981, NASA Authorization, 1979, vol. 1, pp. 543–553. Frosch notes in part: "In our discussions with members of your staff, satellite remote sensing, particularly the use of data from NASA's Landsat satellites, has repeatedly been mentioned as one area where the U.S. is already encouraging developing countries to share in the benefits of space technology. It is an area where promise for still further cooperation with developing countries exists" (p. 543).

[43] House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1978, vol. 1, pt. 1, p. 149.

[44] Ibid., p. 149. In his testimony Dr. Calio cited some of the problems faced with Landsat and the need for more work. "But, in spite of all these difficulties," he said, "the program has been quite successful." And he gave the following example that he termed "typical": ". . . the August LACIE prediction for 1977 U.S.S.R. wheat production was around 90 million metric tons, while the Foreign Agricultural Service at that time was predicting a much greater production in wheat. As you know, we did not get even a forecast from the Soviet Union until about November, but when we got a final assessment in February 1978, it turned out to be somewhere around 91 million metric tons." Thus LACIE indicated earlier than harvest time "that we would have lower production from the U.S.S.R." (p. 197).

In an earlier appraisal of the success of LACIE's Phase III, NASA reported:

"The LACIE results for the U.S.S.R. in Phase III were very encouraging. This is particularly true when it is realized that the 1976–1977 crop year was the only year that LACIE made estimates for the whole country. Using the latest techniques developed and tested in the U.S. Great Plains, LACIE could have underestimated the final U.S.S.R. wheat production (January 28, 1978, Pravda) by 2 percent last July and 1 percent last October. Last August the FAS was overestimating the production by 14.1 percent. The November FAS estimate, after Chairman Brezhnev's November 4 announcement of a poor total grain harvest, was an underestimate of 2 percent.

"During 1977, the LACIE activity produced monthly estimates in the U.S.S.R. using the original LACIE procedure. Those results, while not as good as the 2 percent underestimate in August, were very acceptable. LACIE was making an overestimate of 6 percent using the data and techniques available for analysis in June.

"We feel that this one year of analysis shows the potential of improving early season wheat estimates in the U.S.S.R. using Landsat data." (House Science and Technology Committee, Hearings, 1979 NASA Authorization, 1977, vol. 1, pt. 3, p. 2801.)

For an appraisal of the Landsat series as "proving its worth," see, David F. Salisbury. New Space Satellite to Peer Down on World's Oceans. The Christian Science Monitor, June 20, 1978, p. 7.

Academy of Sciences in the exchange of remote sensing methods and information on surveys of oceans, vegetation, hydrologic, and geologic phenomena. The Survey's efforts focused on the geological and geomorphological fields. The program resulted in the interchange of 70 scientific papers and program documents dealing with geology. In an appraisal of the program, McKelvey stated that the Soviet contributions "have added to the strength of the U.S. views that large geological structures seen on the surface of the Earth in space images are economically and technically significant and that they are global in their occurrence." [45]

In 1980, Secretary of the Interior Cecil D. Andrus reported on another project using the worldwide availability of Landsat data "to accelerate the research and application of remote sensing technology to help meet critical world mineral and energy resource needs." The project included 30 resources specialists from government, industry and academia in the United States and 170 scientists from over 80 foreign countries including the Soviet Union. According to Andrus, "the project provides for technical report exchange, workshops, and guidance on future research efforts." [46]

Thus, while Soviet cooperation in remote sensing has not been extensive, still it stands as an important indicator of an official Soviet attitude toward bilateral space relations with the United States. It also suggests an important ingredient in the success of this particular aspect of the relationship; namely, the factor of reciprocity and the existence of shared interests as binding elements that contribute to success.[47]

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[45] Senate Aeronautical and Space Sciences Committee, Hearings, NASA Authorization for Fiscal Year 1977, 1976, pt. 2, pp.1440–1441.

[46] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, pt. 3, p. 1497. For a statement by Andrus on the importance of Landsat in China's search for minerals and fuels, see footnote 28, page 59.

For a commentary on the role of Landsat in the Nation's mapping program with respect to the search for new energy sources, see the interview with Mr. Rupert B. Southard, Jr., head of the National Mapping Division, U.S. Geological Survey, in Struck, Myron. Mapping the Road to New Energy Sources. The Washington Post, Oct. 19, 1981, p. A13. Struck wrote: "Technology has moved the 1,800-person agency [that is, the National Mapping Division] from the days of the lone surveyor working months on tracts of misbegotten land to cartographers reading data from Landsat satellite imagery, computer-enhanced photographic composites (called orthophotoquads) and high-altitude aerial photographs (useful for soil surveys, range management and urban planning)." "With the country's energy requirement being as acute as they are now," explained Southard, "we've been given new priorities to help find that energy."

[47] For Soviet commentary on remote sensing, particularly from the legal point of view, see, Fyodorov, Y. The Use of Outer Space and Interests of Nations. International Affairs (Moscow), No. 7, July 1978: 16–17, and Kolosov, Space and International Law, pp. 56–58. For an analysis of the problem from both perspectives, see, Jaksetic, Emilio. The Peaceful Uses of Outer Space: Soviet Views. American University Law Review, vol. 28, Summer 1979: 483–506. See also, Toth, Robert C. U.S. Opposes Curbs on Space Photos: Soviet Bloc, Developing Nations Seek to Restrict Data. Los Angeles Times, Mar. 15, 1979, p. 21. For NASA's position on this matter see, statement of Frutkin, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 3, p. 937. Frutkin says in part: ". . . for a decade there have been serious questions raised as to the propriety of one nation's conducting such a [Landsat] program which involves overflight by its satellites of other nations' territories and the acquisition of data relating to that other country's natural resources. The basis on which we have avoided negative action in the United Nations toward such a program, and in fact, gained from the United Nations its endorsement of the program, is the availability of that data to the world." When asked if NASA experienced any objections to its approach to releasing Landsat data, Dr. Fletcher responded: "After almost 5 years of collecting global Landsat data and making it openly available (more than 130 countries have purchased it), there is no known case of protest relating to the dissemination of this data." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, 1977, pt. 2, p. 798.)

SOVIET COOPERATION IN METEOROLOGY AND OTHER ENVIRONMENTAL MATTERS

NECESSITY OF COOPERATION IN GLOBAL METEOROLOGY

International cooperation is vital to the successful global application of space technology to meteorology. Without international cooperation there can be no global meteorological system. That the American approach to space cooperation in meteorology and that of other nations including the Soviet Union is based on this truism is evident in the detailed review of space and global meteorology in the Congressional Research Service study, World-Wide Space Activities.[48] It is also evident in the comments on the subject appearing in NASA's authorization hearings, 1975–81.[49] The exchange between Dr. Fletcher and Senator Harrison H. Schmitt (R–N. Mex.) is a good example of not only the benefits of cooperation in space meteorology but also its effects on the international environment.

> Dr. Fletcher, I believe in terms of pure, broadbased international cooperation, independent of, as much as possible, political ideology, the world weather watch [an international program under the World Meteorological Organization for the application of space technology to weather forecasting] is probably the premiere example of where the national boundaries have started to crumble.
>
> Others, such as COMSAT [Communications Satellite Corporation], tend to be still running up against political boundaries, but the world weather watch, I believe, has just about broken through most of those. Is that right?

To which Dr. Fletcher responded:

> I think that is a pretty fair assessment, Senator Schmitt. The Government has both low altitude weather satellites in polar orbit and high altitude ones in stationary orbit. We have given permission world-wide for people to use them and interpret the data and use it for their own purposes.
>
> In exchange for that, the weather data come in to NOAA [National Oceanic and Atmospheric Administration] at the weather service here in Suitland, Md., from all over the world—from balloons, rockets, aircraft, and satellites. That international program is probably the farthest along in terms of producing good results.[50]

To what extent Soviet-American cooperation in space meteorology may have produced "good results" quantitatively and qualitatively is not apparent in the material reviewed. But there can be no doubt that important agreements on cooperation in meteorology were reached and programs established. As Dr. Fletcher specifically pointed out in a general reference to Soviet-American space cooperation, "There is also a meteorological working group. We have a cooperative program with the Soviet Union." [51]

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[48] See, Raleigh, Lani Hummel. Specific International Applications Satellite Programs. In House Science and Technology Committee, World-Wide Space Activities, 1977, pp. 414–436.

[49] In a commentary on NASA's role in the international effort to study the world's weather, for example, Dr. Calio described the Global Weather Experiment (GWE) which was part of the Global Atmospheric Research Program (GARP). More than 140 nations participated in GWE which Calio said was "the largest scientific experiment ever initiated." He gave the following example of the value of accurate weather forecasts that reflects the necessity for international cooperation in space meteorology: "One day after it [a ground station the United States installed in Dacca at the request of the Bangladesh government] began to receive data from weather satellites of the U.S., the U.S.S.R. and Japan, it tracked a storm in the Bay of Bengal toward a predictable landfall. The populace was evacuated and not one life was lost. In the past, tens of thousands have died when storms struck the coast without no warning." (House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1979, vol. 1, pt. 4, p. 1991.)

[50] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, 1977, p. 2, p. 773.

[51] Fletcher continued: "We have an international program with many countries of the world to measure global weather conditions; hopefully as a result of this program, we will be able to forecast more than the typical 30-hour period that we have now, aiming toward forecasts of 5 days or up to 2 weeks."

CROSS-CALIBRATION TESTS WITH SOUNDING ROCKETS

Tests at Wallops Island with the Akademik Korolev

One aspect of Soviet-American cooperation, especially in space meteorology, were the cross-calibration tests on meteorological rocket systems carried on at Wallops Island, Va. In 1975, the Joint United States/U.S.S.R. Working Group on Space Meteorology agreed to hold these tests to obtain a better understanding of discrepancies in United States and Soviet meteorological rocket data of the Eastern and Western Hemispheres. These measurements were being exchanged under an earlier agreement to investigate the processes which characterize the stratosphere and mesosphere. The purpose of the intercomparison tests was to improve the comparability of the thermodynamic and wind measurements taken by the U.S. Super Loki Datasonde and the U.S.S.R. M-100B meteorological rocketsonde system.[52]

The intercomparison tests were held in August 1977 at Wallops Island. The Soviet hydrometeorological service scientific research ship *Akademik Korolev* participated on the Soviet side. On February 28, 1978, Mr. Norman Pozinsky, NASA's Deputy Associate Administrator for Space Tracking and Data Systems, gave the following report to the Congress:

> I am sure you will recall the stories in the local press last summer concerning the visit to the Eastern shore of the crew of a Soviet ship. That ship was in the area to participate in a data intercomparison test. As you know, both the United States and the Soviet Union coordinate hemispherical meteorology programs for their respective portions of the world. In this way, data gathered in various locales and countries can be aggregated to study weather on a global scale.
>
> However, a joint United States/U.S.S.R. program to exchange data on their respective hemispheric meteorology has discovered consistent variations in data that seem inconsistent with natural phenomena.
>
> In order to eliminate a possible source of error, a program was initiated to conduct a series of simultaneous sounding rocket launches at various locations throughout the world. In this manner, both U.S. and Soviet rocket instrumentation would be sampling the same air masses for temperature, pressure, etc., and differences in the instrument calibrations could be determined during later data analyses.
>
> To carry out this test, a Soviet hydrometeorological research vessel (Figure TC77-3822) was stationed just off the coast of the Eastern shore to fire rockets in conjunction with those fired from the NASA Wallops Flight Center. In all, twenty-two pairs of simultaneous launchings were accomplished. These sounding rocket activities received support from the range instrumentation at Wallops Flight Center which is operated and maintained under our program, and the resulting data calibrations will further research into global weather analysis and forecasting.[53]

Mr. Gerald M. Truszynski, NASA's Associate Administrator for Tracking and Acquisition, reported along similar lines, concluding that the results of the tests "will go far in improving the results coming out of the World Weather program." He emphasized, moreover, that "these tests are illustrative of the cooperative programs that have been going on for some time in NASA and particularly in the sounding rocket program managed by Wallops Flight Center." [54]

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[52] Questions and Response, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 3, p. 953.

[53] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 1, p. 501. For a Soviet commentary on the tests, see, Moscow, Krasnaya Zvezda in Russian, Sept. 4, 1977, p. 3, in FBIS Daily Report: Soviet Union, vol. 3, Sept. 8, 1977, p. B10.

Tests at Wallops Island with the Professor Vize

Other intercomparison tests with the Soviets using sounding rockets were conducted at Wallops Island. In June 1978, the Soviet research ship *Professor Vize* anchored just outside Wallops Island and participated in a Joint American-Soviet Particle Calibration (JASPIC) rocket project.

The ultimate aim of the program, as Dr. Hinners noted, "is to determine whether the nighttime E-region of the ionosphere between 100 and 180 km is due to incoming particles or to solar ultraviolet radiation scattered back by the outer layers of the Earth's atmosphere."

As the first step, JASPIC was to intercalibrate Soviet and American instrumentation so that later on independent measurements could be compared in a meaningful manner. Five Soviet MR-12 rockets were fired from the research ship; three U.S. rockets were fired from Wallops Island. A fourth U.S. payload was reserved for a period of higher geomagnetic activity.

Dr. Hinners gave the following report on the results of the tests:

> Preliminary comparisons of data show satisfactory agreement between the different techniques used by the Soviet and U.S. scientists, indicating that a good foundation has been laid for future steps in this program. Both sides can now proceed to determine how they wish to continue, with full confidence in each other's data. No commitments have been made for future campaigns, but it is expected that further discussions will be held after the final analysis of JASPIC data is completed.[55]

SOVIET ROLE IN GARP

Soviet cooperation in the first experiment of the Global Atmospheric Research Program (GARP) was less successful than in the cross-calibration tests. GARP is a research arm of the World Weather Program that was established as the same time as the World Weather Watch (WWW). The main objective of GARP is to extend the range, scope, and accuracy of weather forecasts and to understand the physical basis of climate and climatic fluctuations. In addition, GARP formulates realistic models of the atmosphere. This task requires observation and experimental studies of the atmosphere supported by the WWW network in order to establish a data base for creating atmospheric models.[56]

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[54] Ibid., p. 433. The continuity of such tests was noted a year before by Mr. Bradford Johnston, Associate Administrator for Applications, NASA, on Mar. 1, 1977: "Finally, in the Sounding Rocket Program, we are continuing the monitoring of stratospheric temperature and winds begun more than a decade ago. We coordinate a Western Hemisphere network of stations and exchange data with the Soviets, who use a pole-to-pole Eastern Hemisphere network. In bilateral discussions with the Soviets, we are also considering using these networks for measurements of minor constituents in the atmosphere, to verify satellite techniques which are global in extent, and to provide vertical dimension detail which is not currently possible with satellite technology." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, 1977, pt. 2, p. 1270.)

[55] House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1978, vol. 1, pt. 1, p. 287. NOAA's report contained this added information: "Ground-based measurements at the Wallops Ionosphere Station were used to monitor local ionospheric conditions for selecting specific launch times. The ionosphere station prepared special analyses of observations for daily briefings to participating scientists and relay to the Soviet vessel. Because of unfavorable ionospheric conditions, the final launch was delayed until Sept. 27, 1978. Results from these measurements may answer differences in past interpretation of ionospheric data in the 80- to 120-kilometer-height range." This additional information suggests not only the degree of intimacy of the cooperation but also the value of the tests. (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, 1979, pt. 3, p. 1390.)

The first GARP Global Experiment (FGGE) was to take place during September 1977 through September 1979. It was to be supported by two polar-orbiting satellites (the U.S. TIROS-N) and five geostationary satellites (two American GOES satellites, in addition to Russian, Japanese, and European satellites). Ships and aircraft were also to complement the coverage from space.[57]

Mr. Leonard Jaffe, NASA's Deputy Associate Administrator for Applications, gave this brief but comprehensive description of GARP:

> The first GARP Global Experiment * * * is a very large scale international program involving the use of meteorological satellites, not only those of the United States, but also those of the Soviet Union, the European Community and Japan. It involves the use of the entire international ground-based complex of weather measuring capability and numbers of ships and aircraft in a concentrated effort to observe global weather for a period of 1 year to provide us with a data set that can be used by the research community in improving our weather models and our forecasting capability. This program has been about 10 years in planning and it is a very large scale program which we think will be very productive.[58]

In this vast and long-planned international effort the Soviets had pledged a geosynchronous satellite to be placed over the Indian Ocean. It was scheduled to be launched in late 1978. But the Russians had to back out of the experiment: In 1978, they announced that they could not provide a satellite, presumably because of technical difficulties in the program. The United States filled the gap with one of their own geostationary satellites.[59]

Nonetheless, the Soviets still continued to participate in GARP as planned, except for the geosynchronous satellite. Asked to explain Soviet participation in FGGE now that they failed to contribute a satellite, Dr. Calio responded:

> The Russians are still participating in FGGE as planned except for geosynchronous satellite. This includes about 10 ships (of about 40 total, more than any other country) for each of the two special observing periods. They also are contributing data from their polar orbiters, Meteor-class satellites which have sounders. They are operating one of the two major data centers for collection of geophysical data which arrives too late for operational use.

Asked if the Russians would continue to receive full access to the data as if they were a full partner, Calio responded: "All data will eventually go into world data centers—one in Washington (EDS) and one in Moscow. Thus, they will have full access to all FGGE data."[60]

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[56] House Science and Technology Committee, World-Wide Space Activities, 1977, p. 552.

[57] Ibid., p. 553.

[58] House Science and Technology Committee, Hearings, 1979 NASA Authorization, 1977, vol. 1, pt. 1, p. 325.

[59] Statement of Calio, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 2, p. 538. Dr. Perry gave this explanation for the Soviet withdrawal: "The Soviet announcement that they would not meet the GARP schedule may simply be a matter of priorities. The Soviet space program, as you know, is dominately military in character, and in fact their total program is under military leadership. There are possible technical reasons: most of the booster types employed by the U.S.S.R. are not suited for placing satellites in geostationary orbits, and they may have experienced difficulty in meeting instrumentation requirements." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 3, p. 1033.)

[60] House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1978, vol. 1, pt. 1, p. 259. When asked about the additional cost incurred by the United States because of the Soviet dropout, Calio answered: "The additional cost to the U.S. resulting from the loss of the Russian satellite is $3.2M to be shared among NOAA, NASA and NSF."

Soviet performance in FGGE was thus mixed. Whatever the reason for their failure to contribute a synchronous satellite, still they did partially fulfill their international obligation by contributing surface ships, polar orbiters, and a major data collection center.[61]

SOVIET ROLE IN SEARCH AND RESCUE SATELLITE EXPERIMENT (SARSAT)

ORIGINS AND AGREEMENT ON SARSAT COOPERATION

Cooperation is imperative in establishing a global meteorological system; it is also imperative in international arrangements for a global search and rescue operation. In these cases, as in so many others in space cooperation, enlightened self-interest binds all participants into achieving a common purpose. Such was the case of the search and rescue satellite experiment (SARSAT) undertaken by the United States, the Soviet Union, Canada, and France.

In the fall of 1976, Dr. Lovelace conferred in Washington with Dr. Boris Petrov, at the latter's request, on possible joint scientific endeavors to be carried out during the next decade. Two ideas surfaced: one, taken on Soviet initiative (already noted above) dealt with monitoring the pollution of the Earth's upper atmosphere, that is, the ozone problem; the other, taken on American initiative related to setting up a global satellite system to pinpoint the location of crashed airliners and ships in distress anywhere in the world.[62] Such a network could improve coverage of distressed air and seacraft, reduce alert time, and provide more accurate initial location.[63] "We suggested this one and the Soviets saw immediate merit in this idea," said Lovelace. "Both sides agreed to look very hard at this suggestion."[64]

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[61] NOAA's reports to the Congress suggest continuity in the Soviet-American exchange of data. In April 1975, NOAA reported: "Exchange of polar-orbiting satellite data continues between the United States and the U.S.S.R. under the auspices of a long-standing bilateral agreement." (Senate Aeronautical and Space Sciences Committee, Hearings, NASA Authorization for Fiscal Year 1976 and the Transitional period, 1975, pt. 1, p. 610.) In March 1977, NOAA reported: "The United States and the Soviet Union continued to exchange environmental satellite data in 1976 under terms of a long-standing bilateral agreement. Russia received data from NOAA-4 and -5, and the U.S. received data from Russia's Meteor series. Russia launched Meteor-23, -24, -25 and -26 in 1976." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1978, pt. 2, p. 940.)

Other instances of Soviet-American cooperation in the areas related to meteorology are recorded in NASA's authorization hearings. A NOAA report of 1977 indicated that the Soviet Union and the United States "continued to exchange satellite cloud pictures during 1977. During the year, the Soviets launched a new series of satellites called Meteor 2. The visible and infrared radiometers on this satellite appear to have environmental monitoring capability close to our IOTS series. Photographs received from the satellite have a resolution of about 2 kilometers. In addition, the United States received data from Meteors 24 through 28 and sent data from NOAA 4 and 5 to Russia." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 2, p. 600.)

In reporting on the current status of "NOAA's Upper Atmospheric Research Program as it Pertains to the Ozone Threat," NOAA recorded an important adjunct to its activities was "involvement, through chairmanship, in the Working Group on the Influence of Environmental Changes on Climate under the U.S.-U.S.S.R. Bilateral Agreement on Cooperation in the Protection of the Environment. The cooperation resulted in the joint U.S.-U.S.S.R. measurement and intercomparison of stratospheric aerosol properties at Rylsk, U.S.S.R., in summer 1975 and at Laramie, Wyo., in summer 1976. Most recently, it resulted in the U.S. acquisition of a Soviet summary on stratospheric ozone, including the first data which have been publicly available in the United States on Soviet estimates of Soviet production and release of chlorofluoromethanes." (Ibid., p. 607.) For further references involving Soviet cooperation in the study of ozone measurements and the attainment of intercalibrations, see, Hudson, Robert D., editor. Chlorofluoromethanes and the Stratosphere. NASA Reference Publication 1010, Scientific and Technical Information Office, August 1977, in House Science and Technology Committee, Hearings, 1979 NASA Authorization, 1977, vol. 1, pt. 1, pp. 1059–1060; see also, statement of Calio, House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1978, vol. 1, pt. 1, pp. 145–146.

[62] O'Toole, Thomas. U.S., Soviet Exploratory Talks Probe Joint Efforts in Rescue Systems. The Washington Post, Oct. 27, 1976, p. A2.

Both sides did, indeed, look into the matter and reached a preliminary agreement in the spring of 1977. On March 18, 1977, NASA and the Soviet Ministry of Merchant Marine agreed on Soviet participation in a planned U.S.-Canadian search and rescue demonstration project using satellites. As explained by NASA, the Soviet side would provide and launch one or more satellites equipped for search and rescue missions and establish ground stations in their country. Soviet activity would be technically compatible and on schedule with the U.S.-Canadian program. Each side would be responsible for their own ground stations and would conduct their own search and rescue operations. The protocol stipulated further that the parties would establish a joint working group to plan the project in detail. (As of March 1978, the joint working group had not met.)[65]

PROGRESS ON SARSAT EXPERIMENT

Progress on SARSAT moved apace during 1977 through 1979, and NASA looked forward with anticipation, and optimism, to "wide international use of such a Search and Rescue System * * * after the initial experimental phase."[66] The Soviet Union and France agreed to join the United States and Canada, and after, apparently, extensive discussions among their specialists, a division of responsibilities was established between all four countries. On March 15, 1979, Arnold Frutkin gave this account of the status of the project, including the division of responsibilities:

> We are close to completing arrangements with Canada, France and the Soviet Union for an experimental satellite-aided search and rescue project. Canada will provide spacecraft repeaters to relay distress signals from ships and aircraft. France will do on-board receiver/processors, which provide initial position location information. These equipments will be integrated by the United States in three polar orbiting environmental spacecraft. The United States will also provide spacecraft antennas. The Soviet Union will provide compatible spacecraft in phase with ours. All four countries will operate ground facilities and demonstrate and evaluate the system.
>
> The United States, Canada and France are near agreement on the text of a Memorandum of Understanding covering their cooperation; we anticipate that this document will be signed within the next few months. Thereafter, an understanding will be concluded among the United States, Canada, France and the Soviet Union

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[63] Statement of Frosch, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 1, p. 60.

[64] The Washington Post, Oct. 27, 1976, p. A2.

[65] Questions and answers, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 3, p. 953. For text of protocol, see p. 955.

[66] NASA Highlights of 1977 Activities, Release No. 77-257, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, vol. 1, p. 23. That the Soviets valued this experiment was evident by the comments of G. S. Khozin in his article, "New Space Exploration Agreement" appearing in U.S.A.: Economics, Politics, Ideology, No. 8, September 1977: "The importance of cooperation in the last field [study of satellite search and rescue systems] is attested to by the fact that around 350 ships and up to 200 airplanes are lost annually as a result of various types of accidents. Joint action by Soviet and American specialists will aid in the organization of more timely and effective assistance for disaster victims." (Translated in, JPRS 69794, Sept. 15, 1977, p. 63.)

confirming the four-party collaboration. Other countries have expressed interest in the project and are considering participation.[67]

By February 1980, all four participants in the experiment signed a Memorandum of Understanding (MOU) that only awaited final certification. Thus, Dr. Calio could report: "The search and rescue program is moving along quite well, within schedule and cost and we expect to begin the experiment in the 1982-83 time frame."[68]

At the same time Kenneth Pedersen gave a full accounting of the project. After discussing the role of France and Canada, he gave the following appraisal of what NASA expected from the Soviets:

> Another MOU related to SARSAT was signed in November between the Sarsat partners and the Soviet Ministry of Merchant Marine, which provides for interoperability between Sarsat and a similar Soviet system known as Cospas. This understanding is awaiting confirmation by the appropriate agencies within these countries, and we expect this confirmation to happen quite soon.
>
> The Soviet Union intends to equip two Soviet spacecraft with transponders and will establish ground terminals in the U.S.S.R. and will be conducting experimental test and demonstration activities. The important thing from the international perspective, Mr. Chairman, is that Soviet participation will be technically compatible with the Sarsat activities and will be conducted at the same time. We believe that this will help improve the system's alert and response times and will give us a more comprehensive test on the basis of which we can determine whether an operational system makes good sense.[69]

SARSAT EXPERIMENT, 1980: FORWARD MOTION

Remarkably, the downturn in Soviet-American relations seemed not to have radically affected the SARSAT experiment. In testimony before the Senate Subcommittee on Science, Technology, and Space, Pedersen explained the state of things, noting at the outset that NASA coordinated its activities with other agencies of the executive branch.[70]

In explaining the "current state of our dealings with the Soviet Union," Pedersen emphasized that NASA has determined "to continue to undertake a number of low level technical exchanges" with the Soviets in accordance with existing agreements—exchange of data, for example, and in some cases an exchange of individual scientists. With the notable exception of the SARSAT experiment, NASA has "deferred or postponed any major undertaking with them." By that Pedersen meant "any joint working group meetings, any large-scale projects which we might have been discussing." The meeting of the interplanetary working group scheduled for March 1980 was "indefinitely postponed," and so the Soviets were advised.

"We have no major meetings or projects currently planned with them," except the SARSAT experiment, Pedersen continued. He then explained NASA's view: "This is worthwhile going forward with on two grounds"; first, the experiment was "essentially a humanitarian activity"; second, "it's a multilateral activity involving

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[67] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, 1979, pt. 3, p. 1661.

[68] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 3, pp. 1300-1301.

[69] Ibid., p. 1650.

[70] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 3, p. 1700.

France and Canada, as well as ourselves and would be detrimental to our own interests as well as theirs to not go forward."

Pedersen explained that the Soviet (COSPAS) and American (SARSAT) were "quite separate systems." They were not interoperable, and thus did not involve an exchange of technology or hardware with the Soviets in any way. Hence, the determination to go forward with the experiment.

In response to the comment by Senator Adlai E. Stevenson (D-Ill.) that, "It sounds as if nothing has changed except new projects are deferred," Pedersen gave a response that was applicable to virtually all cooperative ventures with the Soviets, except SARSAT, in the post-Afghanistan period:

> Well, that's not true. Not only are new projects deferred, but meetings that have been scheduled to discuss ongoing projects as well as the results of ongoing projects have been postponed. We're essentially not carrying on any activity with the Soviets at the moment other than very basic low level technical data exchange.[71]

Still, NASA seemed hopeful that the door would not be closed on this solitary remnant of space cooperation. To be sure, Soviet withdrawal from the project would not have an adverse impact on NASA's planning within the SARSAT partnership. But, as Dr. Calio stressed, "the participation of the Soviet Union will not only enhance the effectiveness of the demonstration but will also contribute to the international acceptance of the system of operational use as envisioned by all parties." [72]

Negotiations on "Hunter-Killer" Satellites—ASAT

PATTERN OF NEGOTIATIONS

A momentary display of Soviet-American cooperation in space occurred during the brief but inconclusive negotiations from 1977 to 1979 to limit satellite interceptors; that is, the so-called "hunter-killer" satellite or antisatellite system (ASAT). Chapter II above examines this issue in the context of space politics and provides a brief account of the sequence of negotiations from the initial U.S. proposal to the failure in Vienna. The point to be emphasized here is the ASAT negotiations as an example of space cooperation, however fleeting, inconclusive, and seemingly fruitless.[73]

Three rounds of negotiations took place in an effort to place limitations on ASAT: June 8–15, 1978, in Helsinki; January 23–February 16, 1979, in Bern; and April 23–June 17, 1979, in Vienna, coinciding with the Carter-Brezhnev summit conference to sign the SALT II Treaty.[74]

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[71] Ibid., p. 1701. Dr. Calio made similar explanations on the difference between the Soviet and American systems to be employed in this mission, and he noted that the project would go forward: "In the event that the Soviet Union unilaterally decides not to proceed with the Joint Project, it would not impact our planning within the SARSAT partnership." (House Science and Technology Committee, Hearings, 1981 NASA Authorization, 1980, vol. 4, p. 1568.)

[72] Ibid., p. 1568.

[73] For an examination of the ASAT issue including a brief resume of the negotiations, see, Smith, Marcia S. Antisatellites (Killer Satellites), Issue Brief No. IB81123. Library of Congress, Congressional Research Service, Science Policy Research Division, Aug. 25, 1981, 17 p.

[74] Ibid., p. 8.

FAILURE IN VIENNA

U.S. objectives in the ASAT negotiations were: To place a ban on satellite interceptors; to require the Soviets to dismantle their system; and finally to provide for verification.[75]

But the obstacles to concluding a successful agreement proved to be much too formidable. They were: The Space Shuttle and Chinese capabilities in space.

The United States rejected any Soviet suggestion that the Space Shuttle be considered a potential antisatellite weapon and thus subject to termination or reduction in capability under an ASAT treaty. An unnamed official close to the talks called the Soviet position on the Shuttle "totally unacceptable." "We would never agree to terminate the Shuttle or even to slow it down," he said.[76]

On their part, the Soviets rejected any arrangement that would restrict their capability to destroy Chinese spacecraft.[77]

In principle, both the Soviet Union and the United States agreed that the other should not "damage, destroy or displace" space objects. Sharp disagreement, however, arose over the specific language of enforcement. The Soviets suggested that only Soviet and American spacecraft be protected. But the United States wanted at least spacecraft "of mutual interest to either country" to be protected by the treaty, if not all spacecraft of all countries. The Soviet position would have allowed them to attack Chinese spacecraft and possibly even those of NATO. The United States would not accept this proposal. The talks, accordingly, stalemated.[78]

HINTS OF FUTURE INTEREST

Despite the failure at Vienna, further talks were planned. But the Soviet invasion of Afghanistan put all arms control negotiations on hold.

Still, U.S. officials, though disappointed by the outcome at Vienna, believed that the Soviets had made positive contributions. They cited as an example the change in the U.S. proposal for a treaty forbidding "hostile acts" against satellites to that of the Soviet proposal that offered more specific language forbidding acts intended to "destroy, damage or displace" satellites. The Soviet proposal was accepted.[79]

Soviet resumption of ASAT testing in April 1980 no doubt dimmed hopes of reaching an accord.[80] But Soviet hints in 1981 to limit weapons in space gave evidence of continuing concern for negotiations on limiting ASAT. On April 17, 1981, 3 days after the successful flight of the U.S. Space Shuttle, Brezhnev used the occasion of presenting awards to two cosmonauts returning from space to state: "May the shoreless cosmic ocean be pure and free of weapons of any kind. We stand for joint efforts to reach a great and humanitarian aim—to preclude the militarization of outer space." [81]

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[75] Chinese Space Gains Hamper Antisatellite Limitation Treaty. Aviation & Space Technology, vol. 111, July 9, 1979:18.

[76] Burt, Richard. Soviet Said to Ask Space Shuttle Halt. The New York Times, June 1, 1979, p. A6.

[77] Aviation Week & Space Technology, July 9, 1979, p. 18.

[78] Ibid., pp. 18-19.

[79] Toth, Robert C. U.S., Soviets Gain Some Ground on Satellite Accord. The Los Angeles Times, July 15, 1979, pp. 1 and 10.

[80] The New York Times, Apr. 19, 1980, p. 28.

Four months later, on August 11, 1981, the Soviets submitted to the United Nations, a draft treaty banning all weapons from space. In a letter to the Secretary General, Gromyko noted that existing international agreements "do not rule out the possibility of the development in outer space of such types of weapons which cannot be defined as weapons of mass annihilation." "The risk of militarisation of outer space," Gromyoko warned, "is maintained and recently has been increased," presumably having in mind the successful Space Shuttle. The Soviets requested that the draft treaty be placed on the agenda of the 36th General Assembly meeting in the fall.[82]

Nor has the United States given up hope completely on an ASAT treaty. In February 1980, when Dr. William J. Perry, Under Secretary of Defense for Research and Engineering, was queried on the status of the ASAT negotiations, he replied, in a much deleted testimony, "We have not abandoned them. We're still pursuing the negotiations." [83]

Thus far the Reagan administration has not announced a position on ASAT negotiations, but Senator Larry Pressler (R-S. Dak.) introduced a resolution in the Senate (S. Res. 129) on May 6, 1981, calling for the resumption of the negotiations. The resolution cited objectives similar to those set forth by the Carter administration; namely, a comprehensive ban; a moratorium on further ASAT testing; dismantling of current ASAT systems; and strict verification. No action has been taken on the resolution.[84]

Thus, negotiations for limiting ASAT remain "on hold." But this also means that they are on the agenda of Soviet-American problems to be managed if not resolved when conditions are right for both sides to turn to arms control, particularly in outer space. When this time comes, they will have a record of past negotiations as a guide. And this record of experience can be an asset in the search for agreement.

Case of Kosmos 954

PARTICULARS ON THE INCIDENT

A unique case revealing an ambivalent side of the Soviet attitude toward space cooperation was the disintegration of Kosmos 954 over Canada in January 1978.

Kosmos 954 was launched on September 18, 1977. The near 5-ton space vehicle was placed in a 150-mile high orbit. An ocean reconnaisance satellite, it was designed to cover the world's oceans from the Arctic to the Antarctic, track ship movements, and transmit by radio collected information to Soviet ground stations. Americans termed it a naval "spy satellite," designed to track the movements of the U.S. fleet. The craft was powered by a 1,000 pound nuclear reactor containing 100 pounds of uranium-235. In about mid-December 1977 the craft began to lose altitude; on January 24, 1978 it reentered the Earth's atmosphere. While most of it apparently burned up on reentry, some of the materials survived and crashed somewhere in the desolate, uninhabited Northwest Territories of Canada. A search for the nuclear remnants was mounted, and on January 30, 1978, the first positive identification of the debris was made.[85]

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[81] Antisatellites Issue Brief No. IB81123, p. 8.

[82] Ibid., pp. 8–9. See also, Austin, Anthony. Brezhnev Hints He Wants Talks on Space Arms Curbs. The New York Times, Apr. 18, 1981, p. 20. For text of the Gromyko letter and the draft treaty on space, see, Moscow Tass in English, 1508, Aug. 11, 1981, in FBIS Daily Report: Soviet Union, vol. 3, Aug. 12, 1981: AA15–AA18.

[83] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 3, p. 1733.

[84] Antisatellites Issue Brief No. IB81123, p. 9.

Cause of the Kosmos 954 failure was unclear. Speculation among specialists in Washington was that the onboard rocket engine normally used to propel the reactor to a higher orbit had failed, but that could not be confirmed.[86]

An official and authoritative Soviet explanation was made on February 4 when Academician Leonid Sedov, a leading Soviet space specialist, told a Tass interviewer:

> On January 6 this year, for reasons not yet clear, a sudden depressurisation of the satellite took place beyond the zone of visibility of our facilities for tracking space objects. Inasmuch as the process of depressurisation was a fast one, it may be assumed that the satellite collided in flight with some other object of natural or artificial origin. As a result, the satellite's on-board systems went out of operation, it lost orientation and began uncontrollable descent. Repeated attempts to bring it back under control unfortunately produced no results.[87]

This explanation was not satisfactory for space specialists, and as late as April 25, Kenneth W. Gatland, space writer for the Christian Science Monitor, wrote from London, "What actually happened to the satellite is still a matter for conjecture." [88]

Whatever the cause, the effects were electrifying, and alarming. Concern focused on the onboard nuclear reactor and the danger it held for radioactive contamination. American and Soviet officials made great efforts to assuage anxieties stirred up by the incident. The initial Tass announcement on January 24 gave assurances of no danger by stressing that the nuclear device was "a small nuclear nonexplosive unit intended as an energy source for the instruments aboard," and that it "was designed in such a way as to be fully destroyed and burned in entering the dense layers of the atmosphere." [89] And U.S. officials attempted to convey the message that this "dramatic-sounding event" should not be the cause of major concern.[90]

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[85] For general accounts of the incident, see, Lyons, Richard D. Soviet Spy Satellite with Atomic Reactor Breaks Up in Canada, Jan. 25, 1978, p. 1; O'Toole, Thomas. Soviet Satellite Burns Up Over Canada. The Washington Post, Jan. 25, 1978, p. Al; Southerland, Daniel. U.S. Minimizes Fall of Soviet Satellite. The Christian Science Monitor, Jan. 25, 1978, p. 1; Leitenberg, Milton. Don't Look Now But * * *: The Soviet Satellite Accident and Some Lessons from it. Commonweal, vol. 105, Sept. 15, 1978, pp. 583-588; and Cosmos 954: An Ugly Death. Time, Feb. 6, 1978:28-29.

[86] The New York Times, Jan. 25, 1978, p. 6.

[87] Moscow in English, 1345 GMT, Feb. 4, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Feb. 6, 1978, p. Ul.

[88] Gatland, Kenneth W. Canada Puts Spotlight on Soviet Satellites. The Christian Science Monitor, Apr. 25, 1978, p. 6. Gatland recorded this explanation from the space department of the Royal Aircraft Establishment at Farnborough near London: ". . . the expected separation of Cosmos 954 from its attached rocket stage and 'platform' did not take place last November, which implies that something had gone wrong much earlier than Academician Sedov suggests. This separation must take place before the satellite can be boosted into a higher parking orbit."

[89] The New York Times, Jan. 25, 1978, p. 8.

[90] The Christian Science Monitor, Jan. 25, 1978, p. 1.

SOVIET AMBIVALENCE IN COOPERATION

The United States discovered the decaying Kosmos 954 on December 19. Official inquiries were made with the Soviets on January 12. During the next 12 days, until the disintegration of the satellite, the United States and the Soviet Union, in the words of The New York Times, "had joined in a secret cooperative effort aimed at minimizing possible radioactive contamination and averting public panic." [91]

But how close was this cooperation?

The chronology of events indicates that the Soviets had not been altogether forthcoming in this cooperative effort. It is clear that the United States had to take the initiative to find out what was happening to Kosmos 954 and to assay its dangers to the world; the Soviets remained silent until approached directly. This failure of notification led James Reston of The New York Times to conclude that the Soviets were "really not very helpful," and that Ambassador Anatoliy F. Dobrynin, upon being informed, gave merely general assurances of no danger. Assuming a defensive posture throughout, Dobrynin provided critical information only when pressed.[92]

That the Soviets were indeed ambivalent, if not outright reluctant, in response to the American request for cooperation is apparent from these facts. Presidential National Security Adviser Zbigniew Brzezinski made the initial inquiry of Dobrynin on January 12. The Soviets replied on the [illegible]h "with unusual swiftness, but without adequate detail," according to Murrey Marder, diplomatic correspondent of The Washington Post. A further inquiry on January 17 brought "more complete answers" on the 19th, according to informed sources. "They didn't give us a tremendous amount of information," this source said, but "we didn't ask for a lot." [93]

President Carter fleshed out these bare facts in an interview on January 27, 3 days after announcement of the Kosmos 954 mishap. The President was asked to explain if he was satisfied with the Soviet response when he asked for information and cooperation on the Kosmos 954 problem. The President gave this long, convoluted, but highly informative response:

> That is hard to say. We had discovered that the satellite was having a problem back in December. I don't remember the exact day.
>
> I made the decision myself to contact the Soviets. We told them we were aware of the problem, asked them for any information about the satellite and told them unofficially that we would not try to capitalize on their misfortune in a propaganda way.
>
> We wanted to be sure that the adequate preparation was made for the re-entry of the satellite into the atmosphere and we notified some of our key allies around the world who would have the capability both to monitor the progress of the satellite and also to des[illegible] the radioactivity once it fell.
>
> I had a difficult decision to make in how much publicity to bring to this satellite because it is almost impossible to let people know the facts without the threat of being exaggerated.
>
> We didn't want to create exaggerated fears. We monitored the satellite constantly. We shared with the Soviets estimates of when it would come down. The exact point of the penetration of the atmosphere was not known until just an hour or two before it crashed because it was tumbling. And when a satellite of that kind enters

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[91] The New York Times, Jan. 25, 1978, p. 1.

[92] Reston, James. Moscow's Forgotten Missile. The New York Times, Feb. 8, 1978, p. A19.

[93] Marder, Murrey. Diplomatic Fallout is Seen in Breakup of Soviet Satellite. The Washington Post, Jan. 27, 1978, p. A18.

> the atmosphere, it can skip off and go several thousands of miles further then you have actually anticipated.
>
> We knew that it would fall somewhere between just north of Hawaii, north-east of Hawaii, or the eastern side of Africa. And it was making a great circle route up above the point where it finally fell. That was just about the northern point.
>
> The Soviets did tell us in general what kind of reactor it was. They told us that their best estimate was it would burn as it entered the atmosphere.
>
> So I can't without going back and checking the exact language of their report to us; I can't say whether they gave us all the facts. But I think it was handled properly; certainly by us.
>
> I don't know who else the Soviets notified. When I found it was going to hit Canada early that morning—I come over here quite early in the morning—I called the Prime Minister of Canada and talked to him on the phone.
>
> We were pretty lucky in telling him where it was going into the atmosphere. We had it on radar. But in retrospect, it may be that the Soviets could have given us more information. I think they probably gave us about what we would have given them under a similar circumstance.[94]

That the Soviets were responsive there seems to be little doubt; but only to a point, and only after some goading.

Much the same can be said about the Canadian experience with the Russians in the cleanup operations. Mr. Erik B. Wang, Director of the Legal Operations Division of the Department of External Affairs, noted that the Canadian Government had appreciated the Soviet offer of assistance in locating, and if necessary, retrieving the remnants of Kosmos 954. But the offer came after the search operation had already begun. Moreover, Wang felt that insufficient data on the satellite's configuration had been received and that the transmittal of some data had been delayed. This reluctance to cooperate led Gerald L. Borrowman, the author of this cited commentary on Kosmos 954, to refer to the "minimal cooperation" the Soviets offered in the cleanup operation.[95]

The Soviets were equally reluctant to respond to Canada's claims for compensation under the Convention on International Liability for Damage Caused by Space Objects.[96] The compensation issue was finally settled in November 1980. The Soviets agreed to pay $3 million for claims resulting from Kosmos 954; the Canadians had sought $6 million.[97] Thus, the case was closed, but only in its compensatory aspects, for Kosmos 954 opened up the whole international question of using nuclear reactors in satellites.

OPENING POSSIBILITIES FOR SPACE COOPERATION

For reasons of traditional Soviet diplomatic behavior (for example, the inclination to maintain an adversarial relationship) and deeper Russian national characteristics (evident in their obsession with secrecy especially in military related matters), the Soviets may not have been as forthright in cooperation in the case of the Kosmos 954 incident as the United States would have wished. But this issue served the larger and useful purpose of internationalizing concern about orbiting nuclear powered satellites, considerations on which would require far-reaching Soviet participation.[98] The need for such cooperation became quickly evident when in a press conference on January 29 President Carter urged the Soviet Union to conclude an agreement barring the use of nuclear-reactor powered satellites.[99] The Soviets themselves, clearly concerned about safety in their use of nuclear reactors, began to seriously address this problem.[100] And finally, under international pressure, led by Canada and backed by the United States and other countries, the matter was brought before the U.N. Committee on the Peaceful Uses of Outer Space.[1]

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[94] Cosmos 954 Incident. Spaceflight, vol. 20, May 1978:184.

[95] Borrowman, Gerald L. In the Wake of Cosmos 954. Spaceflight, vol. 22, March 1980:128–129.

[96] Ibid.

[97] The Washington Post, Nov. 22, 1980, p. A20. For commentaries on the extent of this search effort, see, The New York Times, Apr. 2, 1978, p. 16, and Cosmos 954: The $10 Million Search. Flight International, vol. 113, May 27, 1978: 1643.

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[98] The Kosmos 954 incident provided a platform for editorial commentaries on space cooperation. The Christian Science Monitor concluded an editorial entitled, "Controlling Space Clutter": "The United Nations should give this issue ["effective international regulation of what is sent into space"] serious attention. The time is past for paying lip service to the need for a treaty to regulate use of near-Earth space. If the United States and the Soviet Union led the way, such a treaty probably could be obtained. The incident of the fallen reactor should give them more than enough incentive to do so." (Jan. 26, 1978, p. 24.) The Washington Post, in an editorial entitled, "The Orbiting Reactors," noted that "it surely is time for some serious thinking about what can be done when a satellite—or anything else left in orbit by a space mission—goes out of control." And it concluded with this plea for space cooperation in resolving such issues as ASAT's and errant satellites: "Without such cooperation the problems highlighted by the crash of Cosmos 954 are likely to be with us for a long time." (Feb. 2, 1978, p. A18.)

[99] Asked whether he would try to dissuade the Soviets from mounting reactors in space vehicles, the President replied: "Yes certainly in earth orbit. I think that this is something we should explore. There are two factors, though. One is to try to evolve a sure-fire safety requirement that would . . . prevent a recurrence of any atomic active material reaching the earth or the atmosphere where human beings might breathe it. If we cannot evolve those fail-safe methods, . . . [then] I think there ought to be a total prohibition against earth-orbiting satellites." (The New York Times, Jan. 31, 1978, p. 1.)

[100] While still intending to use nuclear reactors in their satellites, the Soviets, nonetheless, had under consideration plans for destroying them in space. In an interview in February during a visit to Washington, Soviet Academician Yevgeni Federov said: "There is the possibility that we could destroy such a satellite in the future. Such a satellite could be blown up after it has served its purpose in space." Federov, Director of the Institute of Applied Geophysics in Moscow and a member of the Presidium of the Supreme Soviet, made it clear, however, that the Soviet Union would continue launching satellites with nuclear reactors aboard. He noted that they had at least two new types under development: one was designed to relay television programs directly across the Soviet Union; the other was a meteorological satellite designed to carry radar to map storms. Federov indicated that "lessons" could be learned from the Kosmos 954 mishap. Besides equipping such satellites with explosive devices, he said, backup engines could be installed in nuclear-powered satellites to lift them in higher orbits where they would stay for hundreds of years. "We must investigate the possibility to put this cosmic apparat (satellite) after it has served its purpose out of its low earth orbit to a safer altitude," he said. Federov seemed to downplay the reaction to the Kosmos 954 accident, citing the wide use of nuclear power on ships and the incidents of accidents in the past. He did not doubt that "there is danger but the big noise that was made about one satellite is not based on scientific and technical fact." (O'Toole, Thomas. Soviets Will Continue to Use A-Satellites. The Washington Post, Feb. 20, 1978, p. A4.)

The Soviets went to great pains to explain away the accident and downplay the danger it posed. See, for example, Knorre, Elena. Nuclear Energy for Space Exploration. New Times (Moscow), No. 7, Feb. 1978: 21–22. In this fairly technical article, Knorre explains the many areas in space exploration where nuclear energy is used, citing American as well as Soviet work in the field.

In a highly politicized article in International Affairs, Federov ridiculed the U.S. reaction and the "panic" that ensued as evidenced by demands to ban nuclear-powered spacecraft from outer space. Much damage was done to international cooperation, he said, "by the attempts of reactionary circles in Western countries to use U.N. bodies to stoke up anti-Soviet feeling and spread allegations about a 'threat' from the Soviet Union, and for other similar purposes." Federov also downplayed the probabilities of injury from such an accident. He explained the technique of dispatching the satellite to a higher orbit where it would stay "for several thousand years." Any technical device may fail, he said "and a certain amount of risk is always there. But in this particular case it is far smaller than the probability of a car accident or an air crash." (Federov, Y. The Use of Outer Space and Interests of Nations. International Affairs [Moscow], No. 7, July 1978: 12–20.

[1] See the Federov article as an example of Soviet defensiveness on this issue. For commentary on Soviet agreement to participate in a U.N. technical study on safety measures associated with nuclear-powered spacecraft and U.S. plans to raise the question in the UNCOPUOS's legal subcommittee, see, Covault, Craig, Nuclear-Powered Spacecraft Study Set. Aviation Week & Space Technology, vol. 109, Aug. 7, 1978: 44–56.

Continued

But efforts to bring spaceborne reactors under some form of international control have thus far not succeeded. At the United Nations, the United States has sought an international agreement on safety standards governing such reactors, notification of launch, and responsibility for cleanup in the event of an accident. The Soviets have argued that existing regulations, which have no agreed safety codes, are sufficient.

The issue was brought to the fore again on May 1, 1980, when the United States announced that the Soviets had launched a nuclear reactor naval reconnaissance satellite designated Kosmos 1176, the first since the ill-fated Kosmos 954 and termed a "twin" of that spacecraft. The launching was believed timed to observe the American fleet then operating in the Indian Ocean-Arabian Sea area (a record 37 ships) in the wake of the failure to liberate the American hostages in Iran. While no protest was lodged, the State Department, in an expression of "humanitarian concern," criticized the Soviet Union and pledged to take the matter up at the next meeting of the UNCOPUOS in June 1980.[2]

HUMAN RIGHTS AND SCIENTIFIC EXCHANGES

IMPORTANCE OF EXCHANGES

Mutual enrichment

Not quite so dramatic as Kosmos 954 but nonetheless effective in internationalizing an important problem in Soviet-American relations was the impact of Soviet violations of human rights on the international exchange of scientists. That such scientific exchanges have a connection with and thus an impact upon the space sciences

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Igor Morokhov, First Vice-Chairman of the Soviet Atomic Energy Committee, published an article in New Times in July 1978 (No. 27, pp. 26–28) coinciding with the June 26 meeting of the UNCOPUOS that had nuclear power sources in outer space as one item on its agenda. The article explored the many uses of nuclear energy; underscored Soviet safety measures, noting in the case of Kosmos 954 that "Irradiation from the fragments that reached the ground presented no danger to either the population or environment"; and pointed out that "provision is now being made for double safeguards, which should completely rule out any release of radiation from nuclear installations in space devices." Morokhov concluded with a restatement of the Soviet commitment to space cooperation: "Our country attaches the greatest importance to international cooperation under United Nations auspices in the use of nuclear energy in outer space. The value of such co-operation was fully demonstrated by the Cosmos-954 incident. It is to be hoped that the U.N. Committee on the Peaceful Uses of Outer Space will draw up relevant recommendations."

Dr. Robert Greenberg of the Department of Defense explained the U.S. view on the use of nuclear powered reactors in space in an appearance with Dr. Perry before the Senate Subcommittee on Science, Technology, and Space. Greenberg explained that the United States did not use nuclear reactors but radioisotope sources on some U.S. satellites. Seven such DOD satellites were then in orbit using radioisotope generators. "We have no plans to use nuclear reactors in space at this time," he said, "although we think that there is a possibility of using them sometime in the future, as we need more power and perhaps want to increase the survivability of our satellites." Asked if the Kosmos 954 incident affected their thinking, Greenberg replied: "We have considered it pretty carefully. . . . We would not propose to put a nuclear reactor in low Earth orbit, where it would be dangerous, unless we were sure there were a multitude of adequate safeguards to insure that its reentry would be safe." U.S. policy would never have permitted the orbit of Kosmos 954 for an operational reactor. To do so, Dr. Perry interjected, "is completely contrary to the policy under which we would use a reactor in space. They had it operating as a nuclear reactor, while it was in a low Earth orbit, with the idea they were going to boost it to a high Earth orbit afterward." Perry concluded: "That, in itself, is certainly not a fail-safe way of proceeding, as was demonstrated." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 3, p. 995.)

[2] Lyons, Richard D. Soviet Launches a Spy Satellite to Track U.S. Ships. The New York Times, May 2, 1980, p. A3. Getler, Michael. Soviets Again Launch Reconnaissance Satellite Equipped with A-Reactor. The Washington Post, May 2, 1980, p. A16; and the Washington Post, May 3, 1980, p. A10.

is self-evident. For it is believed that the international exchange of scientists enhances the value of science generally, and the space sciences specifically: By encouraging the cross-fertilization of ideas; by stimulating the growth of science as a whole; and by contributing to the unity of the world scientific community.

Impact of detente

Detente in political relations stimulated detente in scientific relations. The easing of tensions in the political realm increasingly held open greater prospects for interaction between the Soviet and American scientific communities. Dr. Bruce Murray, formerly a scientist with the Division of Geological and Planetary Sciences at the California Institute of Technology, and now Director of NASA's Jet Propulsion Laboratory and Mr. Merton E. Davies, senior staff member of the Physical Sciences Department at Rand Corp., concluded a survey of prospects for space cooperation in a period of political detente on this optimistic note:

> * * * we wish to reiterate that person-to-person relations between Soviet and U.S. scientists must be fostered if there is to be the true scientific flowering that can and should accompany detente. Progress must be made toward more intercommunication and openness if detente is to be meaningful to American scientists. The rate of progress in space science may well be dependent on the political fortunes of detente on Earth.[3]

Soviet scientists were also hopeful that fruitful cooperation with their American counterparts would continue as detente flourished. This hope was reflected in a statement prepared by a panel of Soviet scientists and published in Pravda on April 23, 1979. In an apparent effort to divert U.S. criticism of Soviet violations of the human rights of Soviet scientists, they stressed the positive side of Soviet-American scientific cooperation, citing it as a force for peace and progress in science:

> The Soviet Union and the U.S. have very powerful scientific potentials, and successes of science in our countries are exercising a tremendous influence on scientific and technical progress in the world. The constant strengthening and expansion of our scientific ties facilitate the creation of a climate of mutual understanding and trust * * *.
>
> Scientists have a prominent and honorable place in society. Their prestige and contributions to the economic and cultural development of their countries and to the improvement of the international situation are quite weighty. They can and must use their influence for promoting mutual understanding among peoples, deepening the process of detente, and seeing to it that scientific and technical advance is directed toward the good of peoples, toward the solution of mankind's pressing problems.[4]

OBSTACLE TO COOPERATION: INEQUITY OF SCIENTIFIC EXCHANGES

There were, however, obstacles to cooperation in scientific exchanges, and they centered essentially on two points: (1) the inequity in exchanges, to the U.S. disadvantage; and (2) the impact of the human rights issue on Soviet-American relations.

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[3] Murray, Bruce and Merton E. Davies. Detente in Space. Science, vol. 192, June 11, 1976:1074.

[4] Scientific Cooperation and Human Rights: An East-West Exchange of Views. Chemical & Engineering News, vol. 57, Aug. 27, 1979:31-32. The following scientists prepared this statement: Academician Yu. Ovchinnikov, Vice President of the Soviet Academy of Sciences; Academician Ye. Velikhov, Vice President of the Soviet Academy of Sciences; Academician G. Skryabin, Chief Learned Secretary of the Soviet Academy of Sciences; Academicians L. Brekhovskikh and N. Emanuel.

Debate on the quality of Soviet science and scientists was quickened by reassessment of international exchanges in light of Soviet violations of the human rights of their scientists. Briefly, American scientists placed a high value only on certain areas of Soviet science, pointing to the plague of bureaucratic political control as being largely responsible for impairing its advance. That U.S. science was preeminent, there was no doubt. Hence in many ways the exchanges in areas of the hard sciences were uneven. As the Board on International Scientific Exchange of the National Academy of Science concluded in its 2-year assessment published in 1977: "* * * the United States has, on the whole, been teaching the Soviets more than we are learning from them." [5]

Inequity in the exchanges, to the U.S. disadvantage, proved to be, therefore, an important obstacle to expanding scientific cooperation.

OBSTACLE TO COOPERATION: SOVIET HUMAN RIGHTS VIOLATIONS

Systemic incompatability as cause

But Soviet violations of the human rights of their scientists proved to be the most formidable obstacle to cooperation in the sciences—cooperation, that is, not so much at the government-to-government level as noted above as in those exchanges involving Soviet and American scientific institutions and individual scientists.

Causes for the conflict over human rights can be reduced simply to systemic incompatability. As explained in chapter 2, the Soviets and Americans view human rights from politically and philosophically polar opposite perspectives. Special emphasis placed on human rights in the Carter administration inevitably found its primary target in the Soviet Union.

The Soviets, resenting what they termed intrusion into their internal affairs, reacted vigorously against the U.S. campaign. In Soviet efforts to restrict Jewish emigration, allegedly for security reasons since scientists worked with classified information, many Soviet scientists of Jewish heritage became victims of repressive Soviet measures. Non-Jewish scientists such as Andrei Sakharov also suffered in a parallel Soviet attempt to stamp out political dissidence. And since Soviet scientists appeared to be one of the principal Soviet targets, the American scientific community came to their defense, with serious adverse results for cooperative programs including the exchange of scientists.

Peaking of protests with Orlov and Scharansky, 1978–79

The arrest, trial, and harsh sentencing of two Soviet dissident scientists, physicist Yuri F. Orlov and computer scientist Anatoli Scharansky, in 1978 led to an outpouring of protests from the U.S. scientific community as well as the U.S. Government. These harsh repressive measures caused severe strain in Soviet-American scientific relations.

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[5] Quoted in, Cowen, Robert C. Science Swap: Just Politics to Russia. The Christian Science Monitor, Nov. 23, 1977, p. 35.

Among other acts of protest was the cancellation of many scientific conferences in the wake of the convictions of the Soviet scientists. Perhaps Dr. Philip Handler, President of the U.S. National Academy of Sciences, best expressed the mood of the American scientific community in a formal statement. He said that the Academy had told the Soviet Academy of Sciences on the occasion of cancelling a conference in May 1978 that "the issue of human rights threatens to erode the willingness of American scientists to cooperate with their Soviet counterparts." [6]

The protests seemed to peak in March 1979. Under the leadership of the ad hoc committee called, "Scientists for Orlov and Sharansky", or by its acronym "SOS", more than 2,400 American scientists and engineers including 13 Noble laureates pledged in a "statement of conscience" to restrict severely or end their scientific cooperation with the Soviet Union until Orlov and Scharansky were released. At a press conference in Washington, spokesmen for the group, including Nobel Chemistry Laureate Paul J. Flory, denounced the "unjust trials and harsh sentencing" of the Soviet scientists and human rights activitists and expressed SOS's further concern about Soviet scientists suffering for their human rights activities or their desire to emigrate. "And our concern goes beyond," said Flory, to the general treatment of Soviet scientists. The Soviets "have made a mockery of international scientific cooperation," he said, with political criteria for selecting scientists to travel abroad and political restraints on communication with U.S. scientists.[7]

But this action did not mean the complete closing of the door on cooperation. According to Dr. Kurt Gottfried, a physicist at Cornell University, about 70 percent of the 2,400 signatories subscribed to the "statement of conscience." The remainder were not willing to foreclose participation in existing exchanges. But they signed a declaration of principle pledging not to attend international conferences in the Soviet Union, to oppose enlargement of Soviet-American exchange programs, and to campaign against the transfer of sophisticated technology and granting of most-favored-nation status to the Soviet Union. SOS did not advocate that all scientists break scientific ties with the Soviet Union nor that the U.S. Government cut off exchange programs. Rather it supported a spectrum of responses.[8]

Ambivalence of response

The response of the American scientific community to the Orlov-Scharansky case was thus somewhat ambivalent. On the one hand, five Nobel laureates could send a statement to Pravda on July 12, 1979, in rebuttal to the article by Soviet scientists in Pravda of April 23, in which they categorically warned:

> Formal agreements on scientific cooperation are doomed to failure if leading scientists choose not to participate. If the Soviet Government is genuinely eager to cultivate scientific ties and to engage the cooperation of scientists in the world at large,

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[6] Facts-on-File, June 2, 1978, p. 401E1.

[7] U.S. Scientists to Cut Ties with Soviets. Chemical & Engineering News, vol. 57, Mar. 12, 1979:6.

[8] Ibid.

it must foster a climate free of political, ethnic, and racial prejudice and persecution.[9]

But others could take a more moderating view, as in the case of the unidentified American space scientist who said on the occasion of cancelling the conference of physicists in Moscow during the summer of 1978, "We want to keep as many doors open between the two countries as we can." [10]

Much the same tone of moderation was evident in the editorial on Soviet-American scientific relationships by Philip H. Abelson in Science. Abelson evaluated Soviet science; pointed out the shortcomings of the Russians at international meetings and the advantages of bilateral exchanges where their "record is better;" and arrived at this even-handed conclusion:

> It is in our national interest to continue to have interactions with the scientists of the Soviet Union. But the time has come to conduct the relationship on a tough-minded basis. In the process, though, we should remember that some sanctions may injure well-meaning scientists far more than they irritate the Kremlin.[11]

This even-handed, moderate approach to science cooperation with the Soviets had been expressed officially in the 2-year study on Soviet-American scientific exchanges that was prepared by a panel of U.S. scientists and published in 1977. The report acknowledged that "discrimination against Jewish scientists is a particularly sensitive issue, and one which has caused some American scientists to cut off relations with their Soviet counterparts." But on balance, the report said, "the majority of American scientists believe the exchanges should continue despite their disapproval of Soviet discrimination." According to the panel of scientists, "the majority opinion is that Soviet isolation from Western contacts would lead to the worst possible fate for Soviet dissidents." The panel further believed that "maintenance of the exchange will do more to increase the freedom of scientists in the Soviet Union than cutting it off or reducing it substantially would do." [12]

The formal response of Soviet scientists to the "statement of conscience" by their American counterparts was defensive, polemical; but still it struck a positive note by wanting to maintain scientific cooperation.[13]

HUMAN RIGHTS: A DURABLE PROBLEM

However ambivalent the response of American scientists to Soviet violations of the human rights of their scientists, and however moderating the formal Soviet reply may seem, the fact remains that the Orlov-Scharansky case exposed a central problem in U.S. scientific cooperation with the Soviet Union; namely, the problem of human rights from perspectives in conflict. And what is more, this is a durable problem, because it is rooted in the systemic incompatibility of beliefs on human rights and freedom of thought, beliefs that go to the heart of the American approach to science.[14]

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[9] Scientific Ties and Human Rights. Chemical & Engineering News, vol. 57, Aug. 27, 1979:32.

[10] The statement was made as American space officials were about to leave for Europe to confer with the Soviets in Innsbruck, Austria. The U.S. delegation was seeking an agreement with their Soviet counterparts in which American scientific instruments would be flown in an unmanned Soviet spacecraft put into orbit around the Moon. Hence the importance of keeping the door of cooperation open; as that scientist added, "This agreement to fly to the Moon together is one of our best chances to do that." (O'Toole, Thomas. U.S. Seeks Role in Soviet Moon Flight. The Washington Post, May 29, 1978, p. A2.)

[11] Abelson, Philip H. United States-Soviet Scientific Relationships. Science, vol. 201, Sept. 29, 1978:1175.

[12] Gwertzman, Bernard. Science Academy Defends Exchanges with Sovi The New York Times, Oct. 12, 1977, p. A5.

[13] Chemical & Engineering News, vol. 57, Aug. 27, 1979:30-32.

U.S. Space Cooperation With China: The Soviet Factor

BROADENING RELATIONS WITH CHINA AS A U.S. PRIORITY

In order of priority the further broadening of relations with China was perhaps third to the conclusion of SALT II with the Soviet Union and the pursuit of human rights in the Carter administration's foreign policy. Space cooperation was an important aspect of U.S. relations with China, and in pursuing space diplomacy the Soviet factor inevitably entered in. In this case the United States was cautiously playing the so-called "China card," using space cooperation, along with other political, cultural, and scientific agreements, as instruments of pressure against the Russians in a carefully constructed balance of power.

LINKAGE THROUGH COMMUNICATIONS SATELLITES

Early Chinese interest

Communications became the mechanism for establishing and expanding Sino-American space relations. The visit of President Richard M. Nixon to China in February 1972 made it necessary to establish a temporary satellite communications Earth station in China. The purpose was to maintain a continuous communications link between the President and U.S. military and civilian organizations, and to transmit international television and press coverage of the visit.[15]

Subsequent Chinese interest in a permanent linkage with the International Telecommunications Satellite Consortium (Intelsat) system led to negotiations with American firms and eventually the building of permanent satellite terminals in Beijing and Shanghai. American communications specialists visiting China, however, returned with the belief that the Chinese had no immediate plans for a domestic communications satellite system. Not until 1976 was Chinese interest revived by a visit of their representatives to RCA facilities in the United States and Canada. Later in 1976, another Chinese technical team, interested in communications satellites, visited the United Kingdom.[16]

Agreement on Chinese communications satellite, 1979

Chinese interest in a communications satellite system quickened in 1978. During the visit of an American scientific group in July headed by Dr. Frank Press, White House Science Adviser, exploratory talks were held, initiated by the Chinese, on the possibility of the United States building and launching a domestic communications satellite.[17]

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[14] For a review of this conflict over human rights and its impact on scientific exchanges, see, Walsh, John. Local Options Affects U.S.-Soviet Exchanges: American Participation Depends on Choices by Individuals and Some Are Opting Out on Human Rights, Other Issues. Science, vol. 205, Aug. 31, 1979:875–878.

[15] Sheldon, Charles S. II. People's Republic of China. House Science and Technology Committee, World-Wide Space Activities, 1977, p. 215.

[16] Ibid., p. 216.

During November 28, 1978–January 13, 1979, a Chinese space delegation headed by Dr. Jen Hsin-min, director of the China Space Technology Research Institute, visited the United States. An Understanding on Cooperation in Space Technology was reached which stated China's intent to purchase from U.S. industry, under suitable conditions, a satellite broadcasting and communications system, including associated ground receiving and distribution equipment. The satellites would be launched by NASA, according to this agreement, and placed in geostationary orbit by a U.S. contractor, with continued operation to be carried out by China. The Chinese also expressed the intention, again under suitable conditions, of purchasing from U.S. industry a Landsat ground station.[18]

Negotiations on this space agreement were carried on against the background of two important events: On January 1, 1979, the United States and China established formal diplomatic relations; and on January 28, Vice Premier Deng Xiaoping began a 9-day state visit to the United States, including Houston, the space center, aimed at solidifying the newly established diplomatic relations. On January 31, Vice Premier Deng and President Carter signed a series of agreements establishing consulates and creating the basis for extensive undertakings in cultural and scientific affairs. The understanding on space cooperation was attached to the Agreement on Cooperation in Science and Technology.[19] On this occasion President Carter said that the new agreements established "a new and irreversible course" in Sino-American relations. Vice Premier Deng praised the agreements as "significant" and noted that "this is not the end but just a beginning." He added: "There are many more areas of bilateral cooperation and more channels waiting for us to develop." [20]

This was the case with space cooperation. The only areas then under discussion were those enumerated in the January 31 Memorandum of Understanding; but, as Dr. Frosch noted, "Once these are underway . . . there may be further peaceful space activities and cooperative relationships that would be appropriate." [21]

Without delay the Chinese made contact with American firms to undertake specific negotiations.[22]

After the International Telecommunications Exposition, Intelcom 1979 in Dallas during March 1979, Chinese telecommunications executives and technicians conferred with technical and marketing personnel of U.S. and foreign companies and visited telecommunications manufacturing facilities in the Dallas/Ft. Worth area. According to Department of Commerce officials escorting the Chinese, after the group completed its tour and digested the information collected, selected companies would be requested to furnish additional data and then be invited to Beijing for negotiations.[23]

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[17] Weinrub, Bernard. U.S. Agrees to Provide Chinese a Key Communications Satellite. The Washington Star, Oct. 31, 1978, p. A3, and Toth, Robert C. U.S. Reportedly Discusses Sale, Launch of Satellite for China. The Washington Post, Oct. 4, 1978, pp. A1 and A16.

[18] Questions and answers, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, 1979, pt. 2, p. 936. For a copy of the understanding, see part 3 of these hearings, pp. 1671-1672.

Asked to explain what "under suitable conditions" meant, Arnold Frutkin explained: "It's a statement of intent by China to purchase the satellites and launchings, and so on, 'under suitable conditions' and I think this clearly means that the terms of commercial contracts have to be satisfactory to China before they will commit to those purchases." Frutkin informed the committee that China negotiated "somewhat similar arrangements" in Germany and France. (Pt. 3, p. 1653.)

[19] Ibid., pt. 2, p. 936.

[20] Facts-on-File, Jan. 26, 1976, pp. 65A1-AG.

[21] Questions and answers, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, 1979, pt. 2, p. 936.

[22] Statement of Frutkin, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization Fiscal Year 1980, 1979, pt. 3, p. 1653.

In May, Dr. Frosch headed a 13-member delegation of U.S. space officials on a visit to China to discuss cooperative projects between the two countries, including the purchase and establishment of the civil commmunications satellite system. Mr. Richard J. H. Barnes, Deputy Director of NASA's Office on International Affairs, indicated what lay ahead when he remarked: "There's an awful lot of commerical and governmental negotiations to be done before this is completed." Meanwhile, NASA, in anticipation of a contract to orbit a Chinese civil satellite communications network, tentatively scheduled cargo space on two Space Shuttle flights in 1982.[24]

Discussions continued between NASA officials and the newly formed Chinese Communications Satellite Corporation on requirements for the broadcasting and communications satellite, including associated ground receiving equipment which the Chinese assured would be procured from U.S. industry. Upon Dr. Frosch's return from his visit to Beijing, NASA transmitted Chinese invitations to several American space firms to visit Beijing for exploratory discussions. These discussions were undertaken in February 1980.[25] Apparently little more has been achieved; in fact, the Chinese now say that they will launch their own satellite in 1984.

CHINESE INTEREST IN LANDSAT

Communications was not the only space activity that attracted the Chinese. Landsat captured their interest, and, accordingly, in parallel negotiations for a communications satellite network, they discussed its utility with NASA officials. In December 1978, an agreement was reached in principle for the Chinese to establish a Landsat ground station purchased from the United States.[26]

Negotiations went forward in 1979 with officials of the Chinese Academy of Sciences.[27] And after "working steadily" with their counterpart agencies, as Pedersen described the negotiations in February 1980, NASA and the Chinese Academy of Sciences concluded a Memorandum of Understanding on January 24, 1980, governing Chinese participation in the Landsat remote sensing program. According to the MOU, the Chinese would procure from U.S.

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[23] Chinese Tour U.S. Telecommunications Plants. Aviation Week & Space Technology, vol. 110, Mar. 26, 1979:53.

[24] Sulzberger, A. O. NASA Awaits China Decision on Space Flights in 1982. The New York Times, May 18, 1979, p. A13.

[25] Statement of Pedersen, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 3, p. 1651.

[26] Statement of Frosch, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, 1979, pt. 2, p. 875. See also, pt. 1, pp. 540–541. Several other countries also have these ground stations.

[27] Highlights of 1979, NASA News, Dec. 27, 1979, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 2, pp. 817–818.

industry, subject to export control regulations, a ground station to receive data from NASA's Landsat-D satellite.[28]

VALUE OF SPACE COOPERATION WITH CHINA AND THE SOVIET FACTOR

There seems little doubt that China and the United States have benefited from their space cooperation. While both benefited politically, the Chinese benefited far more in space technology. From a technical and scientific perspective, Dr. Louis D. Friedman a congressional fellow sponsored by the American Institute of Aeronautics and Astronautics placed a high value on such cooperation and expressed a favorable view in line with that of other specialists in the space field. In testimony before the Senate Subcommittee on Science, Technology, and Space, Dr. Friedman made the following all inclusive appraisal:

> We also undertake activities on our own aimed at improving the global climate in space. I would like to cite as an example an AIAA recent trip to the People's Republic of China to exchange information on satellite communications and remote sensing from space, a visit which we believe has been of considerable value to both the United States and to the furtherance of international cooperation.
>
> A great deal of science and technical information was exchanged, and the door was opened to U.S. industry to provide a set of communications satellites and Earth stations for the Chinese domestic system.[29]

In the political sphere space cooperation played an important role: It helped to solidify the close relationship then emerging between the PRC and the United States. It also contributed to the evolving American policy of playing the Chinese off against the Russians in a delicate balance of power in global politics; that is, "playing the China card," though this was formally denied.

But the United States, then in the final stages of concluding SALT II, became somewhat apprehensive lest Soviet-American relations deteriorate still further—the Soviet response to the normalization of Sino-American relations and visit of Vice Premier Deng Xiaoping to Washington in January 1979 was to further delay the summit and the signing of SALT II.

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[28] Statement of Pedersen, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 3, p. 1651. For the text of the MOU, see pt. 2 of these hearings, pp. 1047–1049.

The importance of Landsat data to China was evident in the statement of Secretary of the Interior Cecil D. Andrus on international cooperation in fuels and minerals exploration: "G. B. Bailey, and P. D. Anderson (Technicolor Graphic Services, Inc.) and D. G. Orr (Geological Survey), participated in cooperative scientific exchange recently initiated between the Survey and the Peoples Republic of China Scientific Research Institute for Petroleum Exploration and Development. They reported that geologic interpretations based on analyses of standard and enhanced Landsat data acquired over the major portion of China's Tsaidam Basin resulted in the production of a geological structure map with an accuracy (75 to 80 percent) which compared very favorably with a geologic map compiled from ground sources during the past 20 years. The detail of the two maps is also very comparable. The analytic and interpretive work resulting in the Lansat-data derived map was accomplished in approximately 2 man-weeks of time. This accomplishment has great significance for petroleum exploration in this and other remote parts of the world." (Ibid., pt. 3, pp. 1497–1498.)

[29] Statement of Friedman, Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 3, p. 1616.

For an extensive and positive evaluation of Chinese and American space cooperation in communications satellites, see statements of Augustine and Edelson, House Science and Technology Committee, 1981 NASA Authorization, 1980, vol. 5, pp. 2189–21[illegible]2. Both are officials with the American Institute of Aeronautics and Astronautics. Special emphasis was placed on the interaction with the Chinese on technical and scientific matters, surprise at the advanced state-of-the-art in China, and the great commercial opportunities [illegible] the United States in space cooperation with China.

The human rights issue had already cast a pall over the relationship. In July 1978, the United States postponed a visit to Moscow by Dr. Press in protest of the Soviet campaign against Soviet dissidents notably Orlov and Scharansky, and the harassment of American businessmen and journalists. (Recall that Press then led a U.S. scientific delegation to Beijing.) The freeze was kept on scientific and technical exchanges for the next 6 months.

To forestall further deterioration in relations that might threaten the Summit and SALT, the administration decided on January 23, 1979 to reinstate the Press scientific mission to Moscow. Press was cochairman of the joint Soviet-American commission on scientific cooperation. The purpose of the trip was to review the effectiveness of the Soviet-American exchange in scientific areas and explore new areas of potential cooperation.

In this way, therefore, the Soviet factor made its impact on U.S. space relations with China. As one U.S. official said referring to the reinstitution of the Press visit to Moscow, "Let's just say it's part of our effort to be even-handed, or at least not to appear to be tilting toward Peking." [30]

U.S. SPACE COOPERATION WITH THE SOVIET UNION: AN ASSESSMENT

PRIMACY OF POLITICS

Certain generalizations can be made on the Soviet attitude toward space cooperation from this review of Soviet-American space relations during 1976–80; and the first is the primacy of politics.

More than anything else political relations determine space relations: It sets the limits of space cooperation; it determines the degree to which space cooperation becomes an expendable commodity in pressuring an adversary or an expandable asset symbolizing an era of good feeling.

Nowhere is this principle more evident than during 1976–80 in Soviet-American space relations. ASTP was perhaps the highest expression of political detente. Follow-on cooperative programs, at least conceptually, were quickly agreed to by May 1977. But the deterioration of political relations brought on by the collective impact of the human rights issue, the unhealthy tensions created by delays in and misgivings about SALT II, and finally the Soviet invasion of Afghanistan, produced a parallel deterioration in space relations. Since Afghanistan, space cooperation has suffered greatly, being pushed aside and maintained in a holding pattern and entering the picture only in a negative way; namely, U.S. denial of cooperation as a political pressure to demonstrate its disapproval of Soviet conduct.

Space cooperation, therefore, has no life of its own: It is wholly dependent upon politics.

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[30] Beecher, William. The Boston Globe, Jan. 25, 1979, p. 10, and Goshko, John M. U.S. Science Delegation Reschedules Moscow Trip. The Washington Post, Jan. 24, 1979, p. A18.

A PREVAILING REALISM

And yet a prevailing sense of realism was present in some areas of Soviet-American space cooperation, notwithstanding the decline in political relations. The reason for this is simply that both sides would not forego the advantages of cooperative programs that were clearly a vital interest. Hence, negotiations went forward on the search and rescue experiment; and despite failure to reach agreement on controlling ASAT, the Soviets continue to hold out the promise of resuming negotiations.

SOVIET WILLINGNESS TO COOPERATE

Finally, the Soviets demonstrated that they will cooperate in space, not only when there is something in it for them, as in the case of ASTP or GARP, but even when they seemed to be only accommodating the United States though they do receive some compensatory gain if only in the form of data, as in the case of the biosatellite experiments. Nonetheless, negotiations are usually difficult and often drawn out and frustrating; even the end results are not always completely satisfying.

OTHER AREAS OF SPACE COOPERATION

Soviet Cooperation With Communist Countries

ON THE NECESSITY OF COOPERATION

In Soviet-American space relations cooperation is sometimes a necessity; in space relations within the Soviet bloc it is probably always a necessity. Soviet bloc members would seem to have little choice. For the decision had been made sometime ago for them in Moscow. It has been reaffirmed as an enduring Soviet "truth" many times, as when Brezhnev said not long ago, "since the launching of the first artificial earth satellite and the first manned spaceflight, outer space has become a sphere of international cooperation." [31]

The Soviets have placed a high value on space cooperation, particularly with its allies because it has become an integrating force for unity within the Soviet bloc. It is one more instrumentality among others—the political, economic, military, ideological, cultural, and social—for generating a binding loyalty and a sameness of goals and purposes. As Kapitonov described the politics of space cooperation within the Soviet bloc, "Cooperation in the exploration of space is a part of the process of socialist integration in one of the most modern areas of science and technology." [32]

Science and technology have made progress in Eastern Europe, creating the basis for at least some forms of participation in space exploration. And these countries have participated, as it will be shown below, in programs that have served their interests as well as those of the Soviets. That East European leaders have been aware of the benefits to be derived from such cooperation was evident in the statement by the Czechoslovak party leader Jozef

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[31] Kapitonov, International Cooperation in Space, p. 78.

[32] Ibid., p. 83.

Lenart on the occasion of the Soyuz 28 spaceflight in which Czech cosmonaut Remek took part:

> The beautiful sight of the blast-off gave all members of the Czechoslovak delegation confidence that the cooperation of the socialist countries in developing advanced branches of science and technology is moving into a qualitatively new stage.[33]

Lenart emphasized the "great importance" of the "many scientific and technical experiments" placed aboard during the mission, contributing to "the development of the national economies of the socialist countries."[34] Though propagandistic in tone, this statement, nonetheless, contains more than a kernel of truth.

What Lenart had in mind were the many practical applications of space and the potentialities such applications had through the mechanism of space cooperation to be an integrating force for achieving the common goals of communism. A. Koval, a department head in the Soviet Priroda State Scientific Research and Production Center, and Yu. Tyurin, a specialist in the scientific and technical cooperation department of the CEMA secretariat, stated it very simply in the authoritative Soviet publication, Kommunist, "Astronautics is systematically increasing its contributions to the building of communism."[35]

Thus, for Soviets space cooperation is a necessity, compelling but not without benefits; it is "part of the process of socialist integration"; it is an integrating force whose goal is the "building of communism." And the Soviet Union, because it is a superpower in world politics and in space exploration and furthermore because it commands the ultimate power and authority in its East European bloc, determines what that necessity is, what the costs and benefits are to its allies, and plays the role of the enforcer.[36][37]

ASPECTS OF COOPERATION

Organizational arrangements: Interkosmos and Intersputnik

(1) Interkosmos

Organizational arrangements for space cooperation between the Soviet Union, Eastern Europe, and other Communist states (excluding China) were created within two institutions, Interkosmos and Intersputnik.

Interkosmos, the Soviet acronym for the Council for International Cooperation in the Exploration and Use of Outer Space, was established in 1966 within the Soviet Academy of Sciences. Academician Boris N. Petrov was designated as its head, thus lending substance to the judgment of some space observers that Petrov "looks to be the nearest thing to a 'NASA Administrator' in the Soviet system, at least in policy negotiations."[38] While the general task of this organization was to coordinate the work of the various ministries and departments involved in international programs on space research, its primary function was to oversee and coordinate Soviet space cooperation with Eastern European and other Communist countries.[39]

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[33] Moscow Tass in English, 2244 GMT, Mar. 2, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Mar. 3, 1978, p. U5.

[34] Ibid.

[35] Koval, A. and Yu. Tyurin. Astronautics: A Promising Realm of International Cooperation. Kommunist (Moscow), No. 5, March 1978, in JPRS 71106, May 12, 1978, p. 83.

[36][37] An illustration of the point being made here is the conclusion of a protocol in March 1980 between the Soviet-dominated Democratic Republic of Afghanistan and Soviet communications authorities to install two ground stations in Afghanistan "for the exploitation of satellites to receive and transmit television programs and carry out communications services" using the Soviet Intersputnik system. With some 85,000 Soviet troops campaigning in Afghanistan to pacify the country in what is now a 2-year effort, the political and military implications of this protocol are readily apparent. (FBIS 08. Afghan-Soviet Satellite Station Protocol Signed. Kabul in English to Europe, 1900 GMT, Mar. 19, 1980.)

Interkosmos, as a larger entity for intra-Communist space cooperation, had its beginning in November 1965 at a meeting of representatives from Bulgaria, Czechoslovakia, Cuba, the GDR, Hungary, Mongolia, Poland, and Rumania under the leadership of the Soviet Union. Conferees at this meeting drafted a comprehensive plan for space cooperation. Subsequently, after an exchange of views concerning content, forms, and lines of cooperation, a conference was held in April 1967, and a comprehensive plan for intra-Communist space cooperation termed, the Interkosmos program, was formally adopted.[40]

For the purpose of carrying out agreed joint projects under the Interkosmos program, national coordinating bodies called National Agencies were established in the nine member countries. Conferences of the heads of these coordinating bodies have been held annually for the purpose of resolving basic problems relating to the program and formulating new long term tasks for cooperation in space.[41]

The Interkosmos program has covered a broad range of scientific problems that can be broken down into the following five major areas: Space physics, space meteorology, space communications, space biology and medicine, and the study of the natural environment by means of space techniques. Permanent mixed working groups were established to deal with current matters and make decisions on concrete problems within these five areas. These working groups were expected to meet whenever necessary, but at least once a year.[42] During intervals between sessions of the Conference of National Agencies overall coordination in carrying on the work of Interkosmos, according to the 1977 agreement, resided with the Interkosmos Council in Moscow.

Cooperation under Interkosmos did not envisage the setting up of an international secretariat or a common budget. As Kapitonov explained:

> A CMEA country which has no interest in a particular space experiment does not take part in financing it either, which naturally simplifies decisionmaking by the countries concerned. The Soviet Union has made available its space technology to its partners free of charge, so that countries taking part in an experiment have to finance only that part of the work which is projected in joint consultations, the development of instruments and devices for sputniks and research rockets on the basis of cooperation, and so on.[43]

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[38] The 27th IAF Congress, Anaheim, U.S.A. Astronautics & Aeronautics, vol. 14 December 1976, p. 52. The writers were describing Petrov's presentation at the Congress. They noted: "The work of other Academy of Science commissions has now shifted to the Intercosmos Council, and it formulates all international space research, such as the agreement with Comecon of this past June on cooperative space activities. Thus Dr. Petrov spoke with authority, and he gave his remarks from notes with a definite flourish."

[39] Senate Aeronautical and Space Sciences Committee, Soviet Space Programs, 1971–75, pp. 126–127.

[40] Kapitonov, International Cooperation in Space, p. 78.

[41] Koval and Tyurin, Astronautics: A Promising Realm of International Cooperation, p. 86.

[42] Ibid., p. 86, and Kapitonov, International Cooperation in Space, p. 79.

[43] Ibid.

In March 1977, the initial agreement establishing Interkosmos was renewed for another 10 years. In general, the agreement conformed to the earlier instrument in structure and content. Article 2 enumerated the five basic areas of activity noted above; Article 3 spelled out the forms of cooperation in these main areas as follows:

> (a) Launching of space devices for scientific and applied purposes.
>
> (b) Creation of apparatus for the conduct of joint space research.
>
> (c) Experiments using geophysical and meteorological rockets.
>
> (d) Joint observation, experimental and theoretical research on subjects relating to outer space.
>
> (e) Processing, analysis and use of the findings of joint space researches for scientific and applied purposes, and also the preparation of joint publications.
>
> (f) Conduct between interested countries of consultations and, in conformity with special agreements, mutual scientific and technological assistance, including exchange of technology in respect of particular themes and projects in the sphere of the exploration and use of outer space for peaceful purposes.
>
> (g) Symposiums, conferences, seminars, and other meetings.
>
> (h) Exchange of scientific and technological documentation and information.[44]

A review of extensive materials on the Interkosmos program during the period under review seems to support the views of Koval and Tyurin that,

> Comprehensive studies and experiments are being conducted on the Interkosmos satellites. Solar, earth, and interplanetary space physical processes are being studied. The studies are also being conducted on the Soyuz ships, Salyut orbital stations, and "Vertikal" Geophysical Rockets. Meteorological studies are conducted with M-100 and MR-12 rockets as well.[45]

A further indication of the measure of activity within Interkosmos is the statement of Academician Petrov on October 3, 1977 during a press conference commemorating the 20th anniversary of Sputnik. In his remarks Petrov emphasized the versatility of the Interkosmos program, noting particularly that 17 Earth satellites and five geophysical rockets, "Vertikal," had already been launched under this program.[46]

(2) Intersputnik

Intersputnik, the other organization for space cooperation among Communist countries, was established in 1971. Its primary purpose was to provide an international system of space communications, using satellites in space and complexes on the ground. Bulgaria, Hungary, the GDR, Cuba, Mongolia, Poland, Rumania, Czechoslovakia and the Soviet Union concluded an agreement setting up this system in competition with the U.S. supported Intelsat. Centered in Moscow, the Intersputnik International Organization had the responsibility of insuring the proper functioning of the system. According to the agreement, Intersputnik was open to other interested countries.[47]

In building the Intersputnik system, ground stations using Orbita were established in the signatory countries to provide the transmission of color and black-and-white radio broadcasting and telephone-telegraph communications for official use and that of the press. In 1976, a direct telephone communication system was established between Cuba and Czechoslovakia via Intersputnik. Before then such communications were maintained through other countries. Direct satellite telephone communications have existed between Cuba and the Soviet Union since 1974.[48]

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[44] Text of Agreement On Co-operation in the Exploration and Use of Outer Space for Peaceful Purposes. New Times, No. 43, October 1977:30-31.

[45] Koval and Tyurin, Astronautics: A Promising Realm of International Cooperation, p. 86.

[46] Moscow Tass in English, 1553 GMT, Oct. 3, 1977, in FBIS Daily Report: Soviet Union, vol. 3, Oct. 5, 1977, p. U1.

[47] Koval and Tyurin, Astronautics: A Promising Realm of International Cooperation, pp. 86-87.

Participation in experiments

(1) Methodology

A considerable amount of public information on space experiments and on manned spaceflights within Interkosmos is available in Tass reports and in other Soviet and East European sources. A great deal of this material has been translated and reproduced in FBIS publications. Extensive commentaries using Communist sources are also available in American and British journals on space and aeronautics. For the 5-year period of this study, 1975–80, the coverage has been massive. Since the objective in this study chapter is only to suggest the Soviet attitude toward space cooperation, the method chosen here, like that in the chapter on Soviet space politics, is a highly selective one; that is, simply to take a core sample of the data and present it, at best, as evidence of an aspect of this attitude and from it make some tentative generalizations. For convenience the subject is divided into two parts: Participation in experiments using Earth satellites and in manned spaceflights.

(2) The Interkosmos series

Since 1969, the Soviet Union, its allies in Eastern Europe, and other Communist countries, participated in an extensive program of space exploration under the Interkosmos program. Perhaps the most significant project was the Interkosmos series.

On October 14, 1969, the first Earth satellite was launched under the auspices of Interkosmos. It carried scientific instruments developed and made in Czechoslovakia, the GDR, and the Soviet Union. Simultaneously with the measurements being made on board, scientists from seven Interkosmos countries participated in ground-based geophysical and astronomical observations. Interkosmos 1 carried out a study of solar activity and its influence on the Earth's atmosphere.

Studies of the Sun were continued under the Interkosmos program on Interkosmos 4, 7, 11, 16 and on the Interkosmos-Copernicus 500 satellite. In the course of these experiments a number of important results were achieved by instruments developed jointly by scientists of Czechoslovakia, the GDR, and the Soviet Union.

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[48] Ibid., p. 87. For a discussion of the technical aspects of Intersputnik, see, Sheldon, United States and Soviet Progress in space, 1980, p. 83. Sheldon noted that the Soviets had tried to interest other countries in their communications satellite system, "but this had such a poor reception that the plan has advanced slowly. About five years late, Soviet television to Cuba has opened. In late 1975 Intersputnik received a new lease on life with the plan to launch up to eleven large Statsionar satellites in 24-hour synchronous orbit between 1975 and 1980, with five of these longitudinal spots now filled by Ekran, Raduga, and Gorizont payloads. Still more ambitious Soviet plans have subsequently been announced, for 19 more satellite locations registered with the International Telecommunications Union."

Interkosmos-Copernicus 500, launched in April 1973 to mark the 500th anniversary of the great Polish astronomer, was a Soviet-Polish satellite. For 6 months it was used to study sporadic solar radiation and the ionosphere; it also registered flares on the Sun in the given band of wave lengths.[49]

A study of the physical characteristics of the upper layers of the atmosphere and the ionosphere of the Earth was made from Interkosmos 2, 8, 12, and Interkosmos-Copernicus 500. Scientific instruments aboard Interkosmos 2 and 8, developed by specialists from Bulgaria, Czechoslovakia, the GDR, and the Soviet Union, helped to obtain new data on the temperature of electrons and their concentration. A study was also made of the parameters of the upper atmosphere and ionosphere by ground-based stations in Cuba, Hungary, Poland and Romania.[50]

By October 1977, as Dr. Petrov reported, 17 Interkosmos satellites had been launched. A chronicle of Soviet space activity in 1978 recorded the launching of Interkosmos 18 on October 24 to study the interaction of the Earth's magnetosphere and ionosphere. The satellite carried instruments and a telemetric information transmission system designed by Czechoslovakia, the GDR, Hungary, Poland, Romania, and the Soviet Union. Specialists from the participating countries prepared the instruments for the flight and controlled the experiment.[51]

Interkosmos 19 and 20 were launched on February 27, 1979 and November 1, 1979, respectively. Specialists from Bulgaria, Hungary, the GDR, Poland, Romania, Czechoslovakia and the Soviet Union prepared the satellite equipment for launching and contolled the operation.[52]

(3) Other forms of space cooperation

Other forms of space cooperation were undertaken in the Interkosmos program. For example, Vertikal geophysical sounding rockets provided information on the vertical cross-section of the atmosphere and helped measure its parameters at various heights virtually simultaneously. Scientists from Bulgaria, Czechoslovakia, the GDR, Hungary, Poland, and the Soviet Union participated in these experiments.[53]

On November 3, 1978, Vertikal 7 geophysical rocket was launched under Interkosmos auspices. Its task was to continue the comprehensive study of the Earth's atmosphere and ionosphere and of the interaction of short-wave solar radiation and the Earth's atmosphere. According to a Soviet report, at the height of 175 kilometers the stabilized container with scientific instruments designed and tested by Bulgarian, Czechoslovakian, Hungarian, Romanian, and Soviet specialists, separated from the rockets. "The instruments," it was said, "functioned efficiently." [54]

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[49] Kapitonov, V., International Cooperation in Space, p. 79. Kapitonov summarizes the many cooperative programs undertaken within Interkosmos. For a survey of Polish participation in Interkosmos, see, Wolczek, Olgierd. Poland in the Intercosmos Programme. Spaceflight, vol. 22, May 5, 1980:190–192.

[50] Kapitonov, International Cooperation in Space, pp. 79–80.

[51] Facts and Figures: Soviet Success in Space Exploration. International Affairs (Moscow) vol. 5, May 1979:126.

[52] Facts and Figures: Soviet Achievements in Space Exploration. International Affairs, July 1980, vol. 7, July 1980:135.

[53] Kapitonov, International Cooperation in Space, pp. 80–81.

Joint theoretical research into the physics of outer space was also undertaken within Interkosmos. Moreover, specialists in Interkosmos, according to Kapitonov, have been doing "a great deal" on space meteorolgy. Several countries, he said, "are engaged in developing complete ground equipment for receiving data directly from weather satellites, and this will naturally help the weather services to make weather forecasts faster." [55]

Experiments by East European countries were also carried aboard Salyut 6, and numerous experiments were flown in the Kosmos series, such as the biosatellite, Kosmos 936, discussed above in Soviet-American space cooperation.

Joint projects were undertaken in space biomedicine directed at solving problems in space physiology, radiation safety in flight, and protection from ionizing radiation.[56]

Systematic observations by means of optical and recently laser aids were being made on the movement of satellites for the purposes of geodesy and to determine the density of the Earth's upper atmosphere. Successful experiments were staged with the use of laser range-finders developed jointly by scientists of Czechoslovakia, the GDR, Hungary, Poland, and the U.S.S.R. According to Kapitonov, these installations "make it possible to measure the distances to the sputniks, which amount to thousands of kilometers, to an accuracy of one metre." [57]

(4) Attitude of a Czechoslovak scientist toward Interkosmos

That East European scientists take a special pride in their work within Interkosmos and place a high value on the work they are doing, was evident in an interview with Vaclav Bumba, scientific secretary of the Czechoslovak Interkosmos Commission, corresponding member of the CSSR Academy of Sciences, and director of the Academy's Institute of Astronomy in Ondrejov. Bumba made the following points:

> *On Czechoslovakia's share in the Interkosmos program.*—"All 17 Intercosmos satellites and the six vertical geophysical rockets were equipped with our apparatus. Six of the 12 experiments of Intercosmos 17 were our own doing."
>
> *On the quality of Czechoslovak space apparatus.*—"So far our apparatus have worked well. Soviet experts used some of them in the Cosmos and Prognoz satellites and the Mars interplanetary station; we received the results of their measurements in return.
>
> *On the "laser radar for satellite observation."*—"It was based on Czechosolvak laser equipment for geodetical surveys of the earth, produced by the nuclear and physical engineering departments of the Czech Higher Technical College. In Ondrejov it was rebuilt, in cooperation with the experts of other socialist countries, into a radar for observing satellites, which measures distances of thousands of kilometers with a 1 meter precision. Our experts have stationed such radars in Poland, the U.S.S.R., Egypt, Bolivia and India to form an observation network. Now we are building a second-generation laser radar."
>
> *On space medicine.*—"The biological experiments primarily serve the protection of the cosmonauts' health and we have also worked out suggestions, which determine the physiologically most advantageous composition of the atmosphere in spaceships

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[54] Soviet Success in Space Exploration, International Affairs, p. 126.

[55] Kapitonov, International Cooperation in Space, p. 81.

[56] Ibid., p. 80.

[57] Ibid.

for enhancing the crews work capability. We are also conducting research of the ways and means determining the people's higher psychic qualities for spaceflights."

On-board detectors.—"The apparatus for measuring the heat release of the cosmonaut's body and the apparatus for observing the oxygen regime in human tissue, based on the polarograph principle, are both in the testing stage. In the future they are to be included in the equipment of spaceships."

On the practical implementation of space research results.—"This research has enabled the CSSR to participate in the system of Intersputnik communications satellites. Other research improves long-term weather forecasting. Research in space biology and medicine is helping in supersonic airplane flights and various operations involving risk."

On whether the Interkosmos program "will greatly influence our life."—"Precisely so. If the CSSR is to belong to the leading states of the world, this must be so." [58]

Participation in manned spaceflights

(1) Interkosmos cosmonauts: Decision and training

The impression that countries of Eastern Europe and other members of Interkosmos appear to have been deeply involved in a broad range of experiments under Soviet aegis in Interkosmos is fortified by their participation in Soviet manned spaceflights. Involvement has taken on two aspects: The actual participation of Interkosmos cosmonauts as crew members, and their contribution in experiments to be flown aboard Salyut 6.

The decision to integrate Interkosmos into the Soviet manned spaceflight program was taken in Interkosmos during 1976.[59] Cosmonauts from Czechoslovakia, the GDR, and Poland arrived at the Yuriy Gagarin Space Center in December 1976 to begin training. Selection of the candidates from the three most advanced East European countries was believed not to have been difficult since a near decade of participation in Interkosmos had provided a pool of talent.[60] A Soviet pilot cosmonaut with many years of training was expected to command the international flight crew, as indeed was the case. Foreign cosmonauts were to be "flight engineers" and "research engineers." Their main task was expected to be the oversight of the experimental program being carried aboard their particular mission.[61]

The Interkosmos manned flight program was expected to run for 5 years. The total number of foreign cosmonauts in training would not exceed 20 and only half would go into space.[62] By mid-1981, nine had actually flown on Soviet manned space missions, in this order: A Czech, Pole, East German, Bulgarian, Hungarian, Vietnamese, Cuban, Mongolian, and Romanian.

The training of the cosmonauts, as described by Maj. Gen. Alexei Leonov, deputy head of the Gagarin Training Center and himself a ranking Soviet cosmonaut, seemed to be intensive in every respect. The first stage included theoretical studies combined with flight experience in jet planes, physical exercises, simulation of zero-G flights, practicing elementary procedures of splashdown, retrieval by helicopters from thick forests, mountains and other difficult terrain. The second stage consisted in mastering the Soyuz spacecraft and the specific program for a flight to a Salyut space station.[63]

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[58] Interview by Vaclav Bumba. Zemedelske Noviny (Prague), in Czech, Jan. 23, 1978, p. 2, in FBIS Daily Report: Eastern Europe, vol. 2, Jan. 31, 1978, pp. D2–D3.

[59] Koval and Tyurin, Astronautics: A Promising Realm of International Cooperation, p. 87.

[60] Oberg, James. Non-Russians to Join Soviet Cosmonauts. The Los Angeles Times, Feb. 20, 1977, p. 2.

[61] Ibid.

[62] Ibid.

That the Interkosmos cosmonaut program had its political aspects there seems little doubt.[64] This point seems borne out in the concluding statement of an article by Lt. Gen. Georgi Beregovoi, a much decorated Soviet cosmonaut, on the training of international crews that had clear political overtones. Summing up the training program with an enumeration of the list of candidate cosmonauts, Beregovoi quoted Brezhnev as saying,

> * * * this is but the beginning. More will follow. The fraternal friendship and cooperation of the socialist countries have stepped out beyond the earth into the vastnesses of the Universe. This makes us glad and proud.[65]

Yet, as it will be shown below, Interkosmos cosmonauts did participate in the Soviet program in an international cooperative effort, and they did make some contributions, beyond the political, to their assigned missions.

(2) Soyuz 28: Remek spaceflight (Czechoslovak)

Czechoslovakia was to be the first among the countries of the Soviet bloc to send one of its citizens to accompany a Russian into space.

On March 2, 1978, Soyuz 28 was launched with Soviet cosmonaut Col. Aleksei A. Gubarev in command and with Captain Remek, a pilot in the Czechoslovak Air Force, aboard as a "cosmonaut researcher." Soyuz 28 docked with the Salyut 6-Soyuz 27 space station and returned to Earth on March 10, 1978, with Gubarev and Remek aboard.[66]

A variety of experiments were carried out aboard the space station that were either wholly or in part prepared by Czechoslovak scientists and technicians. A Soviet-Czechoslovak chlorella experiment, for example, was undertaken to study the influence of weightlessness on the growth of algae. The Institute of Microbiology of the Czechoslovak Academy of Sciences worked with their Soviet counterparts in preparing this experiment. Czechoslovak scientists from the Institute of Experimental Botany and the Botanical Institute of the Academy of Sciences and from the botany department of Karoly University in Prague also participated.[67]

Another "very important" study was carried out in the Morava Technological Experiment using the Splav 1 installation, according to Koval and Tyurin. This experiment consisted of,

> * * * smelting various metals under conditions of weightlessness in a special electric power furnace located aboard the Salyut 6 Orbital Station and obtaining alloys which can not be achieved on earth due to the force of gravity. Capsules with the materials studied were prepared by Czechoslovak specialists.[68]

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[63] Leonov, Alexei, Maj. Gen. Cosmonaut Training. Spaceflight, vol. 20, Aug. 1978:305–306.

[64] See above chapter 1. James Oberg, a seasoned American observer of Soviet space activities, wrote: "Now as before, politics, public relations, one-upmanship and show business seem to have influenced Moscow's space planning." Oberg noted that the Soviet effort to recruit from its East European allies coincided with the preparation of West European scientists for space missions as part of the U.S. Space Shuttle Program. (The Los Angeles Times, Feb. 20, 1977, p. 2.)

[65] Beregovoi, Georgi, Lt. Gen. The Cosmonaut's Calling. New Times (Moscow), vol. 17, Apr. 1978:23.

[66] The New York Times, Mar. 3, 1978, p. A11, and Mar. 17, 1978, p. A8.

[67] Koval and Tyurin, Astronautics: A Promising Realm of International Cooperation, pp. 89–90.

[68] Ibid., p. 90.

Koval and Tyurin recorded other experiments in which the Czechoslovaks contributed, such as, the Oxymeter experiment to study oxygen in human tissues in a state of weightlessness.[69]

(3) Soyuz 30: Hermaszewski spaceflight (Polish)

Poland was next in line.

On June 27, 1978, the Soviet Union launched Soyuz 30, carrying a two-man crew: Veteran cosmonaut Col. Pyotr Klimuk, commander; and Maj. Miroslaw Hermaszewski, a Pole, cosmonaut-researcher. On June 28, Soyuz 30 docked with the orbital complex Salyut 6-Soyuz 29. On July 5, after completing its mission, Klimuk and Hermaszewski returned to Earth on board Soyuz 30, while Soyuz 29, docked to Salyut 6, continued on its mission with cosmonaut Col. Vladimir Kovalyonok and flight engineer Alexander Ivanchenkov.[70]

During the 7 days in space the Soyuz 30 crew studied the manufacture of semiconductors in space; carried out biomedical examinations on the effects of space flights on human organism; photographed the Earth; and performed technical experiments on the function of individual systems of the complete space complex. Soviet space spokesman cosmonaut Vladimir Shatalov said in an interview that each mission involving an Interkosmos member state reflected, to some extent, the scientific interests of that country. In the case of Poland, it was space technology, space ergonomics and psychology, and a series of medical experiments.[71]

On June 29, according to a summarized account of the mission by space writer Gordon R. Hooper, the crew began the day's program which included the beginning of the Soviet-Polish "Sirena 1" experiment with the Splav furnace. "The 46-hour experiment began in the evening," wrote Hooper, "and involved Hermaszewski placing ampoules containing mercury, cadmium and tellurium in the Splav." Hooper continued:

> The resulting crystal semi-conductor would be one of the most sensitive known detectors of infrared radiation. It could be used for astronomical research, even when the skies are clouded, or when dust and other pollution are present. It could also be used for "super-accurate photography of the Earth's surface" from orbiting stations such as Salyut 6. Such crystals were also said to be essential for ensuring the further development of laser technology, as many lasers operate on IR radiation principles.[72]

PAP, the official Polish news agency, reported details of the experiments performed on the Soyuz 30 flight. Five were from Poland and six prepared jointly by the Soviet Union and Poland, Czechoslovakia and the GDR. The five Polish experiments were summarized as follows:

Sirena.—Materials processing.

Smak (Taste).—Designed to measure taste sensations in weightlessness, (Polish-Vkus).

Relaks (Relax).—Designed to determine the influence of recreation exercises upon the psychological condition of the crew during a lengthy space flight.

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[69] Ibid.

[70] Soviet Success in Space Exploration. International Affairs (Moscow), May 1979, p. 124. See also, Hooper, Gordon R. Missions to Salyut 6. Part 5. Spaceflight, vol. 21, Mar. 3, 1979:127-129.

[71] Ibid., pp. 129-130.

[72] Ibid.

Kardiolider (Cardioleader).—Designed to control the physical effort of a cosmonaut by monitoring the cardiac strain involved and warning of excessive strain by means of a device designed and constructed in Poland.

Zdrowie (Health).—Designed to estimate the physical capacity of a cosmonaut before the start of a mission, and upon landing, by means of equipment designed and constructed in Poland. The device makes it possible to estimate physical efficiency through simultaneous ECG analysis, analysis of the rate of cardiac contractions, automatic control of blood pressure, respiration rate, the volume of lung minute ventilation and the so-called deep temperature of the body.[73]

The experiments were prepared by various Polish research centers and institutes, including the Physics Institute of the Polish Academy of Sciences, the Institute of Aviation Medicine, and the Institute of Geodesy and Cartography. The scientific work was coordinated by the Space Research Committee, chaired by Academician J. Rychlewski.[74]

(4) Soyuz 31: Jahn spaceflight (East German)

For whatever reasons for the ranking, the East Germans were to follow the Poles in going into space with the Russians.

On August 26, 1978, the Soviet Union launched Soyuz 31, carrying a crew of two men: Flight commander Col. Valery Bykovsky, a veteran of the Vostok 5 and Soyuz 22 missions; and cosmonaut researcher Lt. Col. Sigmund Jahn of the GDR. On August 27, Soyuz 31 docked with the orbital space station Salyut 6-Soyuz 29 inhabited by Cosmonauts Kovalyonok and Ivanchenkov. After preforming a 7-day flight program, Bykovsky and Jahn returned to Earth on September 3 in Soyuz 29.[75]

The flight program of Soyuz 31 included medical, biological, and technological experiments, research into physical processes and phenomena in the Earth's atmosphere, and also visual observation and photography of various parts of the Earth's surface and oceans for the study of natural resources. Jahn was the photographer for the mission, using the MKF-6M camera.[76]

More than 20 joint Soviet-GDR experiments were performed on this mission including, according to Gordon R. Hooper:

Syomka.—The photography of various areas of the Earth by means of the MKF-6M camera;

Berolina.—Materials processing;

Audio.—The testing by means of highly sensitive equipment of a person's ability to distinguish the most subtle nuances of sound in outer space;

Vremya.—Obtaining new data about Man's ability to react speedily under the conditions of weightlessness to the commands given to him by an operator or machine;

Reporter.—Research into the conditions of photography inside spacecraft and testing of various types of photographic film.[77]

Hooper's account of the Soyuz 31 spaceflight specificially identified only some of the East German contributions. One experiment called Audio was designed to investigate for the first time during a Soviet spaceflight whether the space environment affected hearing. Preparations for the experiment, together with other medical experiments carried out on this mission, were undertaken at the Koenigsbrueck Aviation Medical Institute.[78]

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[73] Ibid., p. 130. Radio Warsaw reported that 12 Polish experiments had been carried out on this mission, 9 in space medicine, and 1 each in physics, geophysics and "tele-detection" (p. 133).

[74] Ibid., p. 130. For other reports on the Soyuz 30 flight, see, Poland Tries the Taste of Space. Nature, vol. 276, Nov. 9, 1978:110.

[75] Soviet Success in Space Exploration, International Affairs (Moscow), May 1979, p. 125, and Hooper, Gordon R. Missions to Salyut 6. Part 7. Spaceflight, vol. 21, July 7, 1979:318-324.

[76] Ibid., p. 318.

[77] Ibid.

Perhaps the most significant East German contribution to the Soyuz 31 mission was the experiments using cameras built in the GDR. In the Reporter experiment the GDR-designed Prakita EE-2 camera was used. As Hooper explained, Jahn and Bykovsky "collected complete information on methods of photography inside space vehicles and also from onboard the Salyut, in preparation for recommendations on the use of different types of photographic film in space conditions." [79]

In the Polarization experiment the MKF-6m camera was used to determine, as Hooper explained, "the influences of landscape and atmospheric conditions on the accuracy of the guidance of scientific equipment." [80] According to Kenneth W. Gatland, the London-based specialist on space affairs, this multispectral camera "has put the Soviet Union into the forefront of Earth resources survey." Developed by the GDR's Carl Zeiss Jena works, with an assist from the Soviet Academy of Sciences, this camera had been used for the first time, and with very good results, in the Soyuz 22 spaceflight during September 1976. Some 2,000 multispectral photographs of the Earth were taken.[81]

(5) Soyuz 33: Ivanov spaceflight (Bulgarian)

Whatever great expectations the Bulgarians may have had in following the East German pattern, they came to naught: The mission failed.

On April 10, 1979, Soyuz 33 was launched at Baikonur Cosmodrome. Aboard the spacecraft were Soviet commander Nikolai Rukavishnikov, a veteran of two spaceflights, Soyuz 10 and Soyuz 16, and cosmonaut researcher Maj. Georgi Ivanov, a Bulgarian. The flight, programed to coincide with the Soviet celebration of Cosmonautics Day, April 12, called for rendezvous and docking with the orbital complex Salyut 6-Soyuz 32 and Soviet-Bulgarian research and experiments to be carried out jointly with cosmonauts Vladimir Lyakhov and Valeriy Ryumin. According to Tass, a malfunction in the "approach correction power unit" of the space capsule caused the last minute cancellation of the docking operation with the space station.[82] Rukavishnikov and Ivanov were returned to Earth on April 12.[83]

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[78] Ibid.

[79] Ibid., p. 319.

[80] Ibid., p. 320.

[81] Gatland, Kenneth W. Photos from Space Reveal Earth Treasures. The Christian Science Monitor, June 7, 1978, p. 19. See also, Kapitonov, International Cooperation in Space, p. 82.

An indication of the GDR's contribution to Interkosmos was apparent in an article published in Spaceflight (vol. 21, Nov. 11, 1979, p. 442) by Wilhelm Hempel, Presidium Member of the GDR's Astronautical Society. Hempel wrote:

"By autumn 1976 the GDR had developed about 80 onboard and 50 ground instruments for the joint space research projects of Comecon, including highly efficient instruments from the Institute for Electronics, the Centre for Scientific Apparatus Production, the nationally-owned Carl Zeiss factory at Jena, the Robotron Computer works and other institutions.

"With the change from smaller instruments to apparatus of increasing sophistication, systems like the MFK-6 multi-spectrum camera and the high-quality S1-1 Infrared-Fourier-Spectrometer, the demands on the organisers of the cooperative programme increased both nationally and internationally. In the early period of cooperation a single institute or even a small group of scientists and technologists were able to contribute to a space experiment; but today this involves the cooperation of a whole number of institutes and industrial enterprises. Planning has become more complicated and joint projects require steady coordination and synchronisation."

Experiments, some Bulgarian, were to have been performed on the Soyuz 33 mission. According to a booklet released by the Bulgarian mission at the United Nations on April 10 entitled, "Our Road to Baikonur," several experiments developed by the Bulgarians had been flown aboard Soviet spacecraft in the Interkosmos program. Soyuz 33, in particular, was to carry out "a number of investigations in the field of space physiology, hygiene, psychology, radiobiology and protection from radiation." Moreover, Bulgarian "devices and methods will be applied during some of these medico-biological experiments," the booklet said.[84] But the mission was aborted and no experiments were carried out.[85]

(6) Soyuz 36: Farkas spaceflight (Hungarian)

The Hungarians had better luck than the Bulgarians, but only after a delay in their flight of nearly a year because of reported serious trouble with Salyut 6.[86] Soyuz 36 was sent into space on May 26, 1980, with Soviet pilot cosmonaut Valeriy Kubasov in command, accompained by research cosmonaut Bertalan Farkas, a Hungarian. After docking with the Salyut 6–Soyuz 35 space station, where they joined Soviet cosmonauts Leonid Popov and Valeriy Ryumin who had been in space since April 19, the Interkosmos crew carried out their planned flight program, and returned to Earth on June 3 aboard Soyuz 35.[87]

Soviet coverage of the Soyuz 36 spaceflight would seem to bear out the judgment of Academician Petrov in an interview on June 3 that the work of the Soviet-Hungarian crew was "an impressive example of international cooperation in space." According to Petrov, "The scientific centers in Hungary compiled a full program for Farkas. It was not a simple task to carry it out, but I am convinced that our young friend and colleague carried out every task in the flight task log to the letter." This "task log," Petrov noted, required the cosmonauts to carry out 21 experiments ranging from space physics to medicine. Among the more "interesting points" in the program, Petrov listed the making of a new type of semiconductor crystals and research into synthetic interferon, described as "a new medical preparation of the Hungarian pharmacists." [88]

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[82] The New York Times, Apr. 13, 1979, p. A13.

[83] Soviet Achievements in Space Exploration. International Affairs (Moscow), July 1980, p. 134.

[84] Wilford, John Noble. Russian and Guest from Bulgaria on Way to Visit 2 in Space Station. The New York Times, Apr. 11, 1979, p. A20. In the coverage of the ceremonies, apparently, nothing was said publicly about the experiments. Rather great emphasis was placed upon the "courage," "self-possession," and "professional skill" of both men, as Brezhnev had said, in operating the spaceship under "unusually difficult conditions." (Moscow Domestic Service in Russian, 1700 GMT, May 3, 1979, in FBIS Daily Report: Soviet Union, vol. 3, May 4, 1979, pp. U1–U2.) For coverage on the cosmonauts' return, reports from flight control center, landing of Soyuz 33, and Cosmonautics Day, see, FBIS Daily Report: Soviet Union, vol. 3, Apr. 13, 1979, pp. U1–U3.

[85] However, the Bulgarians were progressing in the development of the Bulgarian-Soviet satellite "Bulgarian–1300." According to a Bulgarian report, "the best versions of the Bulgarian equipment" for the satellite were sent to the Soviet Union for trials. The satellite was to be launched in near space in 1981 on the eve of the 1300th anniversary of the founding of the Bulgarian state. The satellite was expected to carry on further research into the ionosphere. Some 70 Bulgarian science and production units were said to be participating in the development of the satellite. (Preparation of "Bulgaria–1300" Satellite. Sofia BTA in English, 1840 GMT, June 9, 1980, in FBIS Daily Report: Eastern Europe, June 10, 1980, p. C3.)

[86] Postponement of the Hungarian flight was announced on June 2, 1979. Rescheduling was not to be expected for 4 or 5 months, possibly even a year. (The New York Times, June 3, 1979, p. 9.)

[87] The New York Times, June 4, 1980, p. A14.

In the press conference on June 12, 1980, Petrov described the Salyut-Soyuz orbital complex as a "multipurpose space laboratory . . . a miniature research institution" that makes it possible "to carry out experiments in the interests of various branches of science—from cosmic physics to cosmic biology and medicine." According to Petrov,

> The program of joint experiments by the international crew . . . was prepared by Hungarian scientists and specialists in cooperation with scientists of the Soviet Union and other countries—participants in the Intercosmos program. The main trends of this research [are] in the field of space physics and geophysics, in particular a study of the earth's atmosphere, exploration of natural resources and the world ocean basin, technological experiments and medical-biological research.

Petrov went on to emphasize that the experiments carried out by the Interkosmos crew were "not only of a scientific, but also of practical significance." He referred particularly to the study of natural resources, new technological procedures, and the "large complex of medical-biological research" carried on in the flight.[89]

Cosmonaut Kubasov reported that during the 8-day flight "11 applied and 13 medico-biological scientific Soviet-Hungarian experiments were carried out." Special attention was devoted to exploring the Earth's natural resources and study of the environment, he said. "Forty visual observations and earth surface photography sessions," he continued, were performed. Kubasov emphasized that the days in orbit were "packed with intensive work." [90]

Farkas made the following general statement of approval of the backup work done by the many Soviet and Hungarian specialists at the Mission Control Center, insuring "a most efficient conduct of experiments": "The whole complex envisaged by the program of experiments has been carried out by us successfully . . . due to the reliable operation of all systems of the spaceship, station and scientific equipment." [91]

Kubasov alluded to the continuity in the Interkosmos program when he took note of the contributions by specialists from the socialist countries and the use of instruments created in the GDR, Poland, and Bulgaria. "This continuity in the work of cosmonauts will remain in the future," Kubasov pointed out. "We have left in orbit instruments designed by Hungarian specialists. The cosmonauts of the other fraternal countries will carry on the experiments, which we started with the use of these instruments." [92]

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[88] Moscow Tass International Service in Russian, 1815 GMT, June 3, 1980, in FBIS Daily Report: Soviet Union, vol. 3, June 4, 1980, p. U2.

[89] Moscow Tass in English, 1412 GMT, June 12, 1980, in FBIS Daily Report: Soviet Union, vol. 3, June 13, 1980, p. U1.

[90] Ibid., p. U1-U2.

[91] Ibid.

[92] Ibid. For a commentary on some of the technical experiments carried on in the Soyuz 35 mission, see, Moscow Tass in English, 1210 GMT, May 30, 1980, p. U2. References are made here to the study of materials in space on the Kristall installation. Two experiments were carried out for the purpose of studying the process of melting, diffusion and crystallization of materials in conditions of weightlessness. Aluminum and copper were used. Refraction and Zarya experiments were also performed along with experiments entitled, "Capacity for Work" and "Audio."

(7) Soyuz 37: Pham Tuan spaceflight (Vietnamese)

For the fifth manned spaceflight with a non-Russian cosmonaut aboard the Soviets turned to its ally in Southeast Asia, the Socialist Republic of Vietnam. On July 23, 1980, researcher cosmonaut Lt. Col. Pham Tuan, a pilot in the Vietnamese Air Force, and flight commander Col. Viktor Gorbatko, a veteran Soviet pilot cosmonaut, were launched into space aboard Soyuz 37. On the following day the spacecraft docked with the orbital complex Salyut 6-Soyuz 36 with cosmonauts Leonid Popov and Valeriy Ryumin aboard.[93] On July 31, after what the Soviets termed "the successful completion of the planned program" aboard the "orbiting scientific-research complex," Pham Tuan and Gorbatko returned to Earth in Soyuz 36.[94]

Scientific experiments were conducted during the Soyuz 37 mission, but Western scientific observers in Moscow generally credited the spaceflight more for its political impact than any intrinsic scientific value.

At the launching Academician Petrov, who was to die a month later on August 26,[95] acknowledged Vietnam as a latecomer in the space sciences, but, nonetheless, he underscored the scientific importance of the flight with the comment, "many original experiments concerned with fundamental and applied problems of space medicine and biology, space technology, mapping of the surface of land and the ocean have been prepared for the Soviet-Vietnamese expedition." [96]

In an interview on July 25, Petrov singled out one of the new experiments prepared by Vietnamese scientists together with Soviet colleagues and specialists in the other Interkosmos countries. The experiment was "connected with studying such complex processes as typhoons and hurricanes. The task is to find out how these transformations start and develop." Asked if this research was important to Vietnam, Petrov replied,

> Yes indeed. This research is particularly important because it is there that these natural phenomena occur and sometimes cause great damage to coastal areas. To be prepared in advance for this, to know about their structure, to evaluate their significance, this is of great importance.

Petrov also stressed the "great significance" of the study of natural resources for Vietnam and "much attention was paid to this," he said. The aim of the research, he continued, was,

> * * * to develop sufficiently precise assessment methods for natural geological formations, to distinguish likely areas for prospecting for minerals, to work out methods of making assessment of the state of crops, forest planting and so on.[97]

From the Vietnamese side, Tran Dai Ngia, Chairman of the National Research Center of the SRV, expressed the gratitude of his country for the scientific opportunity Soviet science had opened to it; took note of the prevailing spirit of cooperation in preparing for the mission; and expressed the hope that,

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[93] Moscow Tass in English, 2054 GMT, July 23, 1980, in FBIS Daily Report: Soviet Union, vol. 3, July 24, 1980, p. U1, and Moscow Tass in English, 0010 GMT, July 25, 1980, in FBIS Daily Report: Soviet Union, vol. 3, July 25, 1980, p. U1.

[94] Moscow Domestic Service in Russian, 1600 GMT, July 31, 1980, in FBIS Daily Report: Soviet Union, vol. 3, Aug. 1, 1980, p. U2.

[95] Moscow World Service in English, 1400 GMT, Aug. 26, 1980, in FBIS 80.

[96] Moscow Tass in English, 2054 GMT, July 23, 1980, in FBIS Daily Report: Soviet Union, vol. 3, July 24, 1980, p. U1.

[97] Moscow Domestic Service in Russian, 2700 GMT, July 25, 1980, in FBIS Daily Report: Soviet Union, vol. 3, July 28, 1980, p. U4.

> * * * even during the short flight we shall manage to lay the foundations for the commencement of work on the first space atlas of Vietnam and to start working on geological, geomorphological and hydrological maps of the country.[98]

The Vietnamese Halong experiment was given special emphasis in the Soviet coverage of the Soyuz 37 mission. Prepared by Soviet and Vietnamese specialists together with those from the GDR, Halong 1, according to Tass, was "devoted to growing crystals of the 'bismuth-tellurium-selenium' system in conditions of weightlessness." The aim of the experiment was "to investigate how conditions of crystallization affect the structure and physical properties of alloys." The purpose of Halong 2 and Halong 3 experiments were "to obtain cylindrical monocrystals with a given structure." During two other subsequent experiments "crystals of gallium phosphide with varying trace element content are being grown," Tass said.[99]

While the Soviets appeared to build up the scientific significance of this latest flight in the Interkosmos program, Western scientific specialists in Moscow downgraded it. Like the other five earlier flights, they said, in the words of the press report, it appeared "to be light on scientific significance and important mainly for its psychological effect. . . ." Greater significance was placed on its political impact in the Third World, especially in Asia, in part because Pham Tuan, a fighter pilot credited with shooting down an American B-52 in the Vietnam war, was the first Asian to go into space. The flight, coinciding with the Moscow Olympics and thus enhancing its propaganda value, was also credited with solidifying Soviet-Vietnamese friendship, a particularly meaningful action at this juncture in the international politics of Eastern Asia. As the Hanoi leaders said in a message to their counterparts in Moscow, the space flight was "an excellent demonstration of the Soviet Union's great and effective assistance to Vietnam" which "proves the superiority of the socialist system."[1]

Some political significance for intra-Communist bloc politics was also evident by the fact that the Vietnamese were given priority over the Romanians in the timing of this flight. At least in foreign policy, the Romanians have insisted upon an independent course, often to the distress of Moscow. A Romanian was not sent into space until May 1981.[2]

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[98] Moscow Tass in English, 1430 GMT, July 26, 1980, in FBIS Daily Report: Soviet Union, vol. 3, July 28, 1980, p. U1.

[99] Moscow Tass International Service in Russian, 1152 GMT, July 30, 1980, in FBIS Daily Report: Soviet Union, vol. 3, July 31, 1980, p. U2. For other Soviet nontechnical commentaries on the experiments performed on the Soyuz 37 mission, see the report from Flight Control Center, Moscow Domestic Service in Russian, 0905 GMT, July 26, 1980, in FBIS Daily Report: Soviet Union, vol. 3, July 28, 1980, pp. U2-U3; and Ryabov, G. A Good Job Done. New Times (Moscow), No. 32, August 1980:12-13.

[1] Austin, Anthony. Vietnam-Soviet Space Effort Ends; Political Impact is Called Extensive. The New York Times, Aug. 1, 1980, p. B4; Sterba, James P. Hanoi Touts Its Astronaut as a Benefit of Moscow Ties. The New York Times, Aug. 2, 1980, p. 3; and Willis, David K. Soviets Bid for Third-World Prestige with Viet Cosmonaut. The Christian Science Monitor, July 25, 1980, p. 3. The political message in the joint statement of congratulations by Brezhnev and the Vietnamese leader Le Duan to the orbiting cosmonauts is self-evident: "The Olympic flame is now burning in Moscow. The 22nd Olympics are proceeding under the sign of the desire of the world's peoples for peace, international solidarity and friendship. These lofty aims are also served by your spaceflight." (Moscow Pravda in Russian, July 26, 1980, p. 1, in FBIS Daily Report: Soviet Union, vol. 3, July 31, 1980, p. U1.)

(8) Soyuz 38: Tamayo spaceflight (Cuban)

The final Interkosmos manned spaceflight in 1980 was assigned to a Cuban military flier, research cosmonaut Arnaldo Tamayo Mendez. Veteran pilot cosmonaut and space hero Yuriy Romanenko commanded the Soyuz 38 spacecraft that carried the cosmonauts into space on September 18, 1980.[3] Soyuz 38 docked with the orbiting space station Salyut 6-Soyuz 37 on September 19 where Romanenko and Tamayo joined Popov and Ryumin who by October 11 were to set a record of 185 days in space.[4] After a weeklong stay with the space complex, Romanenko and Tamayo returned to Earth on September 26.

As if by set formula, Soviet pronouncements on the flight program of Soyuz 38 followed the pattern of the preceding five Interkosmos missions. According to a Tass announcement, the cosmonauts were to perform studies and experiments planned, this time, by Soviet and Cuban specialists. During their 7 days in space they were to conduct visual observations and photograph the Earth's surface for the study of natural resources and the environment. Other experiments were to be performed involving studies of cosmic material and biomedicine.[5]

Subsequent reports on the mission discussed some of the 20 experiments conducted, identifying by name the type of experiment and the country of origin as if to underscore the international character of the Interkosmos program. For example, Tass reported that the cosmonauts would carry out, "Contrast," "Horizon," "Atmosphere," and "Terminator" experiments, which were prepared jointly by experts from the Soviet Union, Bulgaria, and Hungary. The Bulgarian-made Spectr-15 and the multispectral space camera MKF-6M manufactured in the GDR would be used in this experiment.[6]

Experiments prepared by Cuban specialists were also singled out and highlighted as in the case of the medical experiment, "Support." The findings of this experiment, the Soviets said, "will help to evaluate the changes in the structure and functions of the fornix of human foot at zero gravitation."[7] Another experiment using Cuban-made equipment was termed, "the Sakhar experiment," the first of the Carcibba series. The Soviets pointed out that since sugar was the basis of the Cuban economy,

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[2] Vietnamese Cosmonaut Flies on Soyuz. Aviation Week & Space Technology, vol. 113, July 28, 1980:17-18.

[3] Moscow Tass in English, 2130 GMT, Sept. 16, 1980, in FBIS Daily Report: Soviet Union, vol. 3, Sept. 19, 1980, p. U1.

[4] Moscow Tass in English, 0113 GMT, Sept. 20, 1980, in FBIS Daily Report: Soviet Union, vol. 3, Sept. 22, 1980, p. U1, and the New York Times, Oct. 12, 1980, p. 23.

[5] Moscow Tass in English, 0113 GMT, Sept. 20, 1980, in FBIS Daily Report: Soviet Union, vol. 3, Sept. 22, 1980 p. U1.

[6] Moscow Tass in English, 1209 GMT, Sept. 24, 1980, in FBIS Daily Report: Soviet Union, vol. 3, Sept. 26, 1980, p. U1.

[7] Moscow Tass in English, 1536 GMT, Sept. 20, 1980, in FBIS Daily Report: Soviet Union, vol. 3, Sept. 22, 1980, p. U2.

* * * these experiments are of great interest to Cuban scientists and will help in creating mathematical models of these processes, which will, of course, have a bearing on the production of sugar on earth.[8]

AND THE SOVIET ATTITUDE TOWARD INTERKOSMOS COOPERATION

This brief and admittedly cursory review of Soviet cooperation in Interkosmos, based largely on Soviet sources and thus deserving of some skepticism, suggests three points; namely, that the Soviets have been deeply committed to space cooperation with their Communist allies; that they have provided the organizational structure and leadership for such cooperation; and, most important, that they have furnished the means for carrying out its program. In sum, the Soviets demonstrated, at least in their restrictive context, a positive attitude toward space cooperation.

Political motives seem in large measure to underlay Soviet purposes in that space cooperation encourages the forces of East European integration and provides an attractive instrumentality for achieving political gains in international politics, particularly in the Third World. Though the Soviets have had to lay out the hardware and resources to further Interkosmos cooperation, at least to this nonscientific eye, and from scattered judgments of space authorities, they have got somthing in return beyond scoring political points: They have been able to draw upon the scientific and technical resources and skills of their allies.[9]

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[8] Moscow Domestic Service in Russian, 0001 GMT, Sept. 22, 1980, FBIS Daily Report: Soviet Union, vol. 3, Sept. 22, 1980, p. U2.

[9] NASA officials have commented favorably on aspects of the Interkosmos program, often in the context of cooperation and the benefits accrued to the Soviets. With respect to the processing of materials in space, Dr. Calio observed in March 1979: "The Soviet program recently completed a series of about 40 processing experiments aboard Salyut-6 and arranged several rendezvous with their space laboratory. The Soviets now have a data base that will not be available in the U.S. program until 1982." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, 1979, pt. 3, p. 1352.)

During the hearings Dr. Calio called on Dr. Carruthers who was accompanying him to comment on materials processing on Salyut 6. Dr. Carruthers made the following evaluation of this aspect of the Interkosmos program:

"The Russian program moved out quite independently and they also have been building on Apollo-Soyuz experience. They had completed by last summer a total of 14 weeks of experimentation on Salyut 6 and I'm sure you're aware of that. The results of these experiments are just now beginning to be publicized; they are in exactly the same areas in which we are interested. They have had frequent access to Salyut 6. They revisited the space laboratory three times while the experiments were in progress. We have not, however, been able to assess their results in any detail. We have had some preliminary debriefings from the Polish experimenter on Salyut-6. He was invited to the United States in January and completely and openly discussed his research with the scientific community here. So those interactions are beginning to occur. Our general assessment, though, is that the quality of their work is at the level where we left off, in the Skylab and Apollo-Soyuz area, and we feel we both have substantial amounts of work to do to bring our science and technology base further along to make more effective use of the space capabilities that in fact the Russians now have. It's my understanding that they will be doing more materials processing experiments on Salyut 6 within the next few months. The expansion of those capabilities, I think, will depend on the interest of people in the Soviet Union, and here in the materials and industrial communities in taking advantage of the opportunities." (Ibid., p. 1320–1321.)

Other favorable observations have been made on the work in Interkosmos. Congressman James J. Harford, AIAA executive secretary, said in a report on the 28th IAF meeting in Prague: "How sound the Interkosmos program may be cannot be judged from the papers given by Eastern Bloc authors at IAF Congresses. . . . Yet a diligent observer finds evidence of real accomplishment." Harford proceeded to analyze various presentations and favorably evaluate the contents. (Harford, Space Roles for the Less than Superpowers, p. 18.) President Marcel Barrere of the IAF also made a favorable appraisal of Interkosmos. According to a Tass report on the Prague congress, the IAF President "spoke highly of the importance of Interkosmos international programme for the progress of space science and technology. This programme, that unites researchers from socialist countries, is unrivaled by the diversity and uniqueness of its scientific and applied research, he said." (Moscow Tass in English, 2110 GMT, Oct. 1, 1977, in FBIS Daily Report: Soviet Union, vol. 3, Oct. 3, 1977, p. U2.)

Through space cooperation in Interkosmos, therefore, the Soviets seem to have aptly placed space science and technology in the service of their politics and have gained something in both areas for their effort.[10]

As for Russia's East European allies and other member states in Interkosmos, through Interkosmos they have been able to participate in perhaps 20th century man's most dramatic enterprise, space exploration, and by their own assessment and those of Soviet space authorities they have been able to accrue political, scientific, and practical benefits for themselves.[11]

COOPERATION WITH FRANCE

FRANCE: SPACE POWER AND SPACE POLICY

Soviet space cooperation has not been confined to bilateral relations with the United States and multilateral relations within Interkosmos: It has extended to France, a space power in its own right, or as Soviet specialists have designated France, "the world's third space power." [12]

This designation is not an exaggeration, for over the years France has invested much energy and resources into space exploration. The results appear to have been impressive. The French space effort, amply supported by the government and guided by a realistic space policy, has been carried on through its national space agency, Centre National d'Etudes Spatiales (CNES).[13] From the founding of CNES in 1962, French space policy has been marked by two characteristics: Independence and cooperation. As Dr. Hubert Curien, President of CNES, explained in an appearance before the House Subcommittee on Space Science and Applications, "It is a policy which strives to insure our independence to the full extent necessary, and to establish ties of effective cooperation with the space powers, especially with the United States." [14]

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[10] This idea permeates the article by Kapitonov on Soviet space cooperation, particularly in the Interkosmos program. "Cooperation in the exploration of space is a part of the process of socialist integration in one of the most modern areas of science and technology," he declared (p. 83). Proper acknowledgement is given to the role of detente in extending the benefits of space cooperation (p. 83). Finally, Brezhnev's reply to East German leader Erich Honecker on the occasion of the successful launching of Soyuz 22 and the Raduga experiments on board underscores the collective benefits to be derived from Interkosmos: "This space experiment, prepared by the scientists, engineers and workers of the Soviet Union and the GDR and carried out by Soviet cosmonauts, testifies to the close cooperation of our countries in the exploration and use of space for peaceful purposes, and in the interests of the economy and science of the U.S.S.R. and the GDR, and of the whole socialist community" (p. 82).

[11] In an interview with Tass special correspondent Aleksandr Romanov, Lt. General of the Air Force Vladimir Shatalov, head of the cosmonaut training program, member of the Interkosmos Council, and a veteran cosmonaut, commented extensively on the cooperative aspects of the Soviet space program and the practical benefits derived. During 1975-80, he said, "more than 20 Soviet researchers and seven researchers from fraternal socialist countries worked outside the earth." He pointed out the practical significance of this effort, saying, "More than 400 economic, research, technical and production organizations representing various branches of Soviet economy are interested in this exploration. According to estimates of experts every rouble invested into outer space exploration ensures a return of up to 10 roubles." In commenting upon "the most characteristic features" of space exploration in the past 5 years, General Shatalov said that "the idea of space exploration by the joint efforts of people has reached new practical heights in the outgoing five-year plan period." Regular flights of international crews have been started, bringing together with Soviet researchers representatives of Czechoslovakia, Poland, the GDR, Bulgaria, Hungary, Vietnam, and Cuba. "The pooling of the research and technical potential of the peoples of the socialist community," Shatalov stressed, "brings wonderful results for their economy and science. The academies of sciences of the member-countries of the Interkosmos Programme have received useful data about natural resources, about the state of habitat, the regularities of the atmosphere, the sun-earth interrelationship and many other things." In brief, Shatalov said, during this period "solid scientific-technical groundwork has been laid for the cosmonautics of tomorrow." All of this effort and success, he concluded, "points out the necessity of a further study and exploration of outer space in the interests of science, technology and the national economy." (Moscow Tass in English, 1132 GMT, Dec. 11, 1980, in FBIS Daily Report: Soviet Union, Dec. 12, 1980, vol. 3, pp. U2-U3.)

[12] Vereschchetin, V. and S. Terrunin. Soviet-French Cooperation in Space. International Affairs (Moscow), vol. 11, Nov. 1978:79.

[13] For a discussion of budgetary allocations in the French space effort, see, Ropelewski, Robert R. French Pursue Own Space Programs. Aviation Week & Space Technology, vol. 108, June 12, 1978:21-22.

France has carried on an extensive program of space cooperation not only with the United States but also with the Soviet Union. Bilateral space relations with the Soviets were established during a visit to Moscow by President Charles de Gaulle in 1966. Since then, they have been expanded progressively, and impressively, under the succeeding governments of Georges Pompidou and Valery Giscard d'Estaing.[15] Curien acknowledged that, "The scope of Franco-Soviet cooperation in the space field astonishes and sometimes even disconcerts our American colleagues." But, he explained, giving a realistic rationale for French policy, "This cooperation which we consider very fruitful, can be accounted for in several ways":

> Firstly, the structure of cooperation with the Soviet Union is such that the clearer the definition of the objectives, the better the results. Space science and technology lend themselves well to such definition, and this has led to a certain focusing of scientific cooperation in this field.
>
> The second reason is that it results from a political determination expressed by the French President, Charles de Gaulle, and which has never been queried.
>
> A third reason is obviously the great benefit which accrues to us from this cooperation through the scientific and human caliber of our counterparts and the powerful means at their disposal.

And as a result, Curien concluded, "* * * relationships, habits, and friendships have been built up which confer on this cooperation its full value." [16]

ASPECTS OF SOVIET-FRENCH COOPERATION IN SPACE

Organizing for cooperation

The mechanism for managing Soviet-French space cooperation has been the Permanent Mixed Soviet-French Commission, referred to by the Soviets as the "Great" commission. Annual meetings of the commission, attended by about 50 scientists and technicians from each country, provide a forum for assessing ongoing programs and defining new ones. Joint working groups composed of scientists and specialists of both countries have been formed to deal with specific areas of common interest, such space-related activities as, communications, meteorology, biomedicine, physics, and planetary exploration.[17]

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[14] Statement of Curien, House Science and Technology Committee, Hearings, International Space Activities, 1978, pp. 2-3.

[15] For a review of Soviet-French space cooperation during 1966-75, see, Senate Aeronautical and Space Sciences Committee, Soviet Space Programs, 1966-70, pp. 432-436; and Soviet Space Programs, 1970-75, vol. 2, pp. 121-123.

[16] House Science and Technology Committee, Hearings, International Space Activities, 1978, p. 5. Asked to compare the magnitude and significance of U.S. cooperative activities with those of the Soviet Union, Frutkin responded: "Soviet cooperative programs developed much later than ours did, and I think we can say quite safely that they are patterned on ours and motivated by ours. So they are much more recent in origin and much more limited in extent." With respect to Soviet-French cooperation, Frutkin said that it "has been rather extensive, but that is about the limit of Soviet cooperation. There is not the exchange of data. There is not any program that begins to compare with, say, our Helios program with Germany or of course the Spacelab program with ESA." Asked if he saw any indications that such programs may be impending, Frutkin replied: "I personally would not anticipate the Soviets entering into a program which involved such an intimate association with another country as our programs do." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1980, 1979, pt. 3, pp. 1648-1649.)

Planetary exploration

Soviet and French scientists have cooperated in planetary exploration, sufficiently important in itself to attract the attention of NASA officials.[18] In 1977, a large number of space officials from each country (55 from the Soviet Union) conferred in Marseilles, France on the planned 1983 Soviet-French balloon and orbiter mission to Venus, designated Venera 83. The French balloon system (by 1978, France had launched some 1,500 stratospheric balloons and 300 research rockets and placed some 20 satellites in orbit) that was to be carried to Venus on a Soviet-launched rocket was designed to float at about an altitude of 55-km. (34-miles) above the planet carrying a 150-kg (330-lb.) instrument gondola. A large Soviet orbiter spacecraft was to carry the balloon canister to the vicinity of Venus. This joint Soviet-French mission was the first of its type to be undertaken.[19] For the French it would be the first time that they played a role in planetary exploration. The purpose of the Marseilles meeting was to set up joint working groups to discuss the scientific and hardware questions relating to the 1963 mission.

In addition to this cooperative effort, the French had supplied the Soviets with an instrument in 1977 for use on a Venus mission to be launched in 1978. The French delivered an ultraviolet spectrometer for placement on a craft that they believed would be a Venus orbiter.[20] They were not familiar with any Soviet Venus landers, Aviation Week reported, that potentially could be launched on the 1978 mission.

Soviet-French preparations for Venera 83 caught the attention of NASA officials. In authorization hearings for fiscal years 1979 and 1980, Dr. Hinners expressed the hope that discussions could be arranged for U.S. participation in the mission.[21]

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[17] Statement of Curien, House Science and Technology Committee, Hearings, International Space Activities, 1978, p. 5, and Vereshchetin and Petrunin, Soviet-French Cooperation in Space, pp. 29–30

[18] For a summary statement and brief commentary on the wide range of Soviet-French cooperative programs see, House Science and Technology Committee, World-Wide Space Activities, 1977, pp. 169–170; see also, Vereshchetin and Petrunin, Soviet-French Cooperation in Space, pp. 30–32.

[19] French Agency, NASA Discuss Increased Cooperation in Space. Aviation Week & Space Technology, vol. 107, Nov. 7, 1977:25.

[20] Ibid.

[21] In discussing Soviet activity in planetary exploration, Dr. Hinners said: "A joint U.S.S.R./French mission is planned for 1983. This is the same opportunity we are studying for a potential Venus Orbiting Imaging Radar (VOIR) mission. We believe there are several areas of cooperation that would significantly enhance the scientific return from these missions and are proposing the initiation of discussions between the U.S. and U.S.S.R. of the various options." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, vol. 1, p. 385.) For other comment by Hinners, see, House Science and Technology Committee, Hearings, 1979 NASA Authorization, 1977, vol. 1, pt. 1, p. 33. With respect to the difficulty in getting the Soviets to talk about future programs, he said: "We would also like to coordinate with them on that mission possibly to avoid any duplication of objectives and to achieve a complementary Venus exploration program. It has been difficult in the past to get the Soviets to talk about their future programs. We are trying once more to crack that particular nut and do see signs that they are more willing now than in the past to talk about the future, particularly with regard to Venus. We will try to work that in detail in November." Hinners discussed the mission again in, House Science and Technology Committee, Hearings, 1980 NASA Authorization, 1979, vol. 1, pt. 3, pp. 1525–1526.)

The French had first offered the balloon mission to the United States a decade ago, but the proposal elicited no interest. The Soviets also showed little interest—until 1972, when they sent two spacecraft through the clouds of Venus for the first time. As French scientist Jacques Blamont recalled, the Russians came to him and asked, "Let's talk about the balloons." By that time the United States was committed to the Pioneer mission. Blamont aptly expressed the French view toward cooperation with the Soviets when he remarked:

> This has been the only possibility for French scientists to go into the planetary programs. There are some individuals like me who have had instruments on U.S. spacecraft but we'd like to have a larger constituency and the only way for our scientists to go to the planets is through this cooperation with the Soviets.[22]

(In the spring of 1981, the newest Venera plan eliminated the French balloons that were to have been released in the Venus atmosphere. As envisioned under the revised plan the mission will consist of a pair of lander/probe spacecraft that will be launched in late 1984/early 1985.)[23]

Signe 3; other experiments and programs

An experiment that drew high praise from both Soviet and French space scientists was Signe 3, a French Earth satellite launched by a Soviet rocket on June 17, 1977. In preparation for 2 years by space researchers at the Toulouse Space Research Center and the Space Research Institute of the Soviet Academy of Sciences, Signe 3 was a small automatic observatory with telescopes designed to detect and locate the sources of little studied types of cosmic radiation (gamma flashes).[24]

According to the French director of the project Antoine Miosi, the experiment was carried out under a strict division of labor: The Soviets being responsible for the launching; the French having designed the satellite and the scientific equipment carried aboard. So many changes were made in the design at the suggestion of Soviet colleagues improving the experiment that Miosi said it would be more correct to call Signe 3 a Soviet-French satellite. Hence his gratification with the results of cooperation with Soviet specialists.[25]

The Toulouse Space Research Center controlled the flight and would process the data, Miosi noted. Processing the data was estimated to take more than a year, after which it would be transmitted to the Soviet Academy of Sciences for study. The final results would be discussed at a joint meeting of Soviet and French scientists.[26]

A week before the launching of Signe 3, Academician Petrov heralded the experiment as ushering in the second decade of Soviet-

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[22] O'Toole, Thomas. France and Soviets Will Aim Wind Balloons at Venus. The Washington Post, Dec. 17, 1978, p. A31.

[23] French Participation in Soviet Venus/Halley Mission Modified. Aviation Week & Space Technology, Apr. 27, 1981:52. For an earlier report on the revision of the Venera plan, see, Soviets Revise 1984 Venera Unmanned Mission. Aviation Week & Space Technology, Nov. 10, 1980:18.

[24] Vereshchetin and Petrunin, Soviet-French Cooperation in Space, pp. 31-32; and Moscow Tass in English, 1608 GMT, June 17, 1977, in FBIS Daily Report: Soviet Union, vol. 3, June 20, 1977, pp. U1-U2.

[25] Ibid., p. U2.

[26] Ibid.

French space cooperation. Dozens of "rare experiments, important for science," he said, in the words of Tass, were carried out in the first decade: French-made instruments were carried aboard Lunokhod vehicles, Mars and Venera spacecraft, Oreol and the Prognoz station; [27] Soviet rockets launched the French-made satellites MAC 1 and 2 accompanied by Molniya 1 satellites in experiments that, according to Vereshchetin and Petrunin, "served to prove the effectiveness of the thin-film elements for solarbatteries and the serviceability of a radiation cooling system"; [28] in the Araks experiment, a French rocket placed into orbit a Soviet electron accelerator to study the nature of the Polar lights. Petrov further pointed out that joint meteorological and geophysical research was continually being carried on at Soviet and French test ranges, and that the joint program on space biology (for example, flights of experiments aboard Kosmos 936 and 1129) was being regularly renewed.[29]

Other experiments could be added to this catalog of space cooperation before and during the period under review: The Arcade 3 experiment to study the Earth's ionosphere and magnetosphere to be carried out in 1981; [30] Soviet and French participation in the U.S.-Canadian Search and Rescue Satellite Mission; (SARSAT) in which France will provide equipment valued at $4 million; [31] the use of French materials in experiments aboard Salyut 6; [32] and finally, the Soviet offer, and French acceptance, to fly a French astronaut aboard a Soyuz spacecraft to Salyut 6 in 1982.[33]

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[27] In March 1978, the last recordings of spectra in the remote ultraviolet sphere were received from the Prognoz 6 automatic high-apogee station, Tass reported, marking "the successful conclusion of the joint Soviet-French space experiment." On board the station, launched from the Soviet Union on Sept. 22, 1977, was a Galaktika instrument developed and manufactured jointly by scientists and specialists at the Crimean Astrophysical Observatory and the Marseilles Space Astronomy Laboratory. Academician Andrey Severnyy, director of the Crimean observatory, said, "It has been used to obtain valuable scientific material—more than 4,000 spectra have been recorded by the remote ultraviolet sphere, individual stars and star clusters." "We hope that with further study of the spectra by Soviet and French scientists," Severnyy concluded in the words of Tass, "new data of importance for science will be obtained on the physical condition of the goecorona and on the density of the hydrogen atoms and free electrons in the Earth's vicinity." (Moscow Tass International Service in Russian, 1004 GMT, Mar. 4, 1978, in FBIS Daily Report: Soviet Union, vol. 3, Mar. 6, 1978: U8.)

[28] Vereshchetin and Petrunin, Soviet-French Cooperation in Space, p. 30.

[29] Moscow Tass in English, 1608 GMT, June 17, 1977, in FBIS Daily Report: Soviet Union, vol. 3, June 20, 1977, p. U2. See also, Knorre, E. U.S.S.R.-France: Joint Research in Space. New Times, No. 14, April 1979, pp. 8–9; and Vereshchetin and Petrunin, Soviet-French Cooperation in Space, pp. 30–32.

[30] Moscow Tass in English, 1301 GMT, Feb. 6, 1980, in FBIS Daily Report: Soviet Union, vol. 3, Feb. 8, 1980, p. U1. Oreol 1 and Oreol 2 were launched in 1971 and 1973 in accordance with the Arcade program. They carried scientific equipment designed in the Soviet Union and France to explore physical phenomena in the upper layers of the Earth's atmosphere.

[31] Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 2, p. 701.

[32] Knorre, U.S.S.R.-France: Joint Research in Space, pp. 8–9; and Chernyshov, Mikhail. Russian Report: The Salyut Again. Space World, June-July 1979:33–35. Samples prepared by French scientists were used in the Kristall experiment using the new electrical melting furnace. Knorre described the Citos experiment, noting that it was designed "to trace the dynamics of growth at cellular level in the conditions of a space flight. Obtained for the first time were time graphs of cell division on two different biological objects in cosmic conditions, data that will be valuable when preparing for prolonged space voyages."

[33] Two French Air Force fliers were selected to begin training in the Soviet Union, Lt. Col. Jean-Loup Chretien and Major Patrick Baudry, one of whom would join a Soviet cosmonaut for the space flight. At a press conference to introduce the two trainees, Prof. Pierre Morel, deputy director of the National Space Research Center of France, said that the forthcoming flight would become, in the words of Tass, "a new and important stage in the development of Soviet-French cooperation in space exploration which has already many accomplishments." (Moscow Tass in English, 2052 GMT, June 11, 1980, in FBIS Daily Report: Soviet Union June 12, 1980, p. G1.) For a description of the training program being given the French spacemen, see, Lenorovitz, Jeffrey M. French Cosmonauts Begin Intensive Soviet Training. Aviation Week & Space Technology, vol. 113, Sept. 29, 1980, p. 22.

Satisfaction on both sides

Judging by even this brief review, space cooperation between the Soviet Union and France appears to have been impressive. No doubt both sides gained scientifically, politically, and economically through their cooperative efforts. And on many occasions, in documents of the "Great" commission and in the course of meetings and talks between the scientists and national leaders, they expressed satisfaction with their space relations. The Soviet-French Declaration, adopted in June 1977 during a meeting between Brezhnev and Giscard d'Estaing, reiterated a shared view on achievements of the past and expectations of a fruitful future when it said:

> A landmark in Soviet-French cooperation in space, which has successfully and steadily developed throughout the last decade was the putting in orbit of the French Signe 3 satellite with the help of a Soviet carrier and subsequent months will see the participation of French scientists in the Soviet Union's programme to explore Venus.[34]

The French have viewed their space relations with the Soviets in the clear light of realism, balancing independence with cooperation in the hope of achieving France's best national interest. "Cooperation with your country in space research is very important and advantageous to us," said Jean-Claude Husson, director of the Toulouse Center for Space Research.

> We are carrying out a very extensive programme of joint experiments to study the Earth, the Sun, the planets and the Universe. Through this kind of cooperation, either country can avail itself of its partner's achievements. Detailed discussions with our Soviet colleagues of long-term programmes of experiments make it possible to plan in advance the most interesting and important research.[35]

What Professor Curien told Soviet journalists about the "great importance" of Soviet-French cooperation was very much in line with his statement to the Congress, cited above: "Out of all the world's nations, except the socialist ones, France is the U.S.S.R.'s major partner in the exploration of outer space. We know how to value such relations."[36]

And finally Werner Estadier, deputy head of the Toulouse Space Center, expressed the same sentiments of satisfaction when he told Yevgeniy Shulyukin, Trud's Paris correspondent, on the occasion of the first press conference of the Soviet-French space crewmen at the Yuriy Gagarin Cosmonauts Training Center in October 1981:

> The Soviet Union is a great space power, which possesses immense technical and scientific possibilities. . . . We are very satisfied with the development of this cooperation. If not for it we would have to reduce substantially our programme. Now, French cosmonauts are training for joint flights with Soviet space explorers.[37]

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[34] Vereshchetin and Petrunin, Soviet-French Cooperation in Space, p. 33.

[35] Ibid., p. 32.

[36] Ibid.

[37] It was announced at the press conference that the principal crew included flight commander Yuriy Malyshev, flight engineer Aleksandr Ivanchenkov, and French cosmonaut researcher Jean Loup Chretien. The backup crew was headed by Leonid Kizim, an experienced cosmonaut. Flight engineer Vladimir Solovyov and French cosmonaut researcher Patrick Baudry were described as "novices." The joint space mission is scheduled for mid-1982. (Moscow Tass in English, 1700 GMT, Oct. 20, 1981, in FBIS Daily Report: Soviet Union, vol. 3, Oct. 20, 1981, p. G6.)

The French connection with the Soviets in space is, therefore, important to them, and important to the Soviets.

Soviets exploit opportunity in NASA budget cut

Just how important this connection has been to the French was evident in 1981 when the Reagan administration proposed to cut back severely or terminate American participation in a variety of international scientific and technological programs. Endangered by this proposed action was the International Solar Polar Mission, a joint venture to fly twin spacecraft—one from the 12-nation consortium European Space Agency (ESA), the other American—over opposite poles of the Sun to make scientific observations. Another result of the administration's cutbacks was the decision not to end a probe to Halley's comet that in late 1985 and early 1986 will return to the vicinity of the Earth.[38]

The European reaction, particulary that of France, West Germany, and Japan in the Far East, was, according to The New York Times, one of "injured indignation, dismay and anger." M. Jean-Pierre Fouquet, the space attache at the French Scientific Mission in Washington, expressed the official French view with exceptional candor when he said:

> We prefer to cooperate with the United States for politcal reasons. We worked hard for this. Our only alternative is to say to the Soviet Union, "Are you ready to cooperate with us?"

Fouquet pointed out that 90 percent of French-American cooperation in space would be lost if the solar mission were dropped, leaving, as the Times said, "dozens of French scientists in the lurch." [39] The measure of ESA's commitment was apparent in the fact that it had already spent $100 million on the "solar-polar" mission.[40]

So severe was the reaction in Western Europe that ESA formally protested the proposed cuts to the State Department; France threatened to cease cooperating with the United States in international space missions; and other nations presented aide-memoires to the State Department, urging that the budget cuts affecting such missions be restored.[41]

The U.S. decision not to send a U.S. probe to Halley's comet created the severest reaction. Critics said that the action meant that the most serious study of Halley's comet would be left to the Soviet Union. In response to the proposed cutback in NASA's budget, the Soviets upgraded their Halley's mission, making it more international. Jacques Blamont, chief scientist in ESA and a renowned French space scientist, perhaps best expressed the French view when he said:

> We see this as a reverse trend of what used to be the case. The Russians now appear as a promoter of international cooperation, the Americans . . . as a demoter of cooperation.[42]

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[38] Reinhold, Robert. U.S. Dismays Allies by Slashing Funds for Joint Science Projects. The New York Times, May 10, 1981, p. 1, and O'Toole, Thomas. Study of Halley's Comet Periled: Proposed U.S. Space Budget Cuts Vex Allies. The Washington Post, Mar. 20, 1981, p. A8.

[39] The New York Times, May 10, 1981, pp. 1 and 17.

[40] The Washington Post, Mar. 20, 1981, p. A8.

[41] Ibid.

[42] Ibid.

The Soviets, seizing the opportunity by the American decision not to perform a Halley's intercept, agreed to fly one of its own spacecraft as close as 1,000 miles from the head of Halley's comet. It also agreed to have the craft carry an improved camera to be built by France, Hungary, and Czechoslovakia.[43]

As a consequence of the U.S. budgetary action, apparently taken unilaterally, abruptly, and without consultation among its Allies, the United States will not be mounting a Halley's mission; the French have chosen to cooperate with the Soviet Union; ESA has begun its own mission; and the Japanese will prepare their first deep space probe with their Halley's project.[44]

Whatever the final outcome of NASA's budget reductions, the point being made here is, (1) that in space cooperation the Soviet Union represents a potential alternative whenever the United States decides to withdraw from the space scene; and (2) that in the case of the French their choice was based upon this reality and upon nearly two decades of agreeable space cooperation with the Soviet Union.

COOPERATION WITH INDIA

INDIA'S COMMITMENT TO SPACE EXPLORATION

Expanding space relations with France opened up potential opportunities for the Soviets to influence the French politically, particularly in seeking the much cherished Soviet foreign policy goal of dividing the West. In the case of India, space cooperation was to play a similarly unique political role, that of an instrument for expanding Soviet political influence in this leading country of the Third World, and thus furthering its larger purpose of linking the Third World to the Soviet Union's expected global destiny.[45]

By the mid-1970's, India had given ample evidence of its commitment to space exploration. From its modest beginning in 1961, it had developed, mainly with the assistance of the United States, the Soviet Union, and France, a respectable infrastructure for space exploration. With the fourth largest pool of scientific manpower in the world, India had the brainpower to master the complexities of building a space program.[46] By 1979, it could boast that over 6,000 scientists, engineers, and technicians were employed at such space centers as the Thumba Equatorial Rocket Launching Station (TERIS) and the launching site at Sriharikota; and at those centers devoted to research, such as, the Vikram Sarabhai Space Center (VSSC) at Trivandrum, the Space Applications Center (SAC) at Ahmedabad, the National Remote Sensing Agency (NRSA) of the Department of Science and Technology, and the Experimental Satellite Communication Earth Station (ESCES) at Ahmedabad.[47] India's NASA is the Indian Space Research Organization (ISRO).

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[43] Ibid.

[44] Terry, Sara. NASA Must Find $25 Million in the Next Few Months If It Wants to Loft Even Scaled-Down Missions in 1985. The Christian Science Monitor, June 24, 1981, p. 1. It is important to note that the United States wanted to put experiments on ESA's Halley's mission, but ESA refused.

[45] For an extensive commentary on Soviet policy in the Third World, see, House Foreign Affairs Committee, Soviet Third World Policy and U.S. Response, ch. 2.

[46] Mama, H. P. India's Space Program: Across the Board on a Shoestring. Interavia, vol. 35, January 1980: 60.

From its beginning, according to P. Nandakumar, an observer of Indian space activities, India has had two basic objectives in its space policy:

> * * * to build up indigenous capability in all aspects of space technology, applications and research, and to utilize the expertise so gained for the good of the country and for the benefit of its people.[48]

To achieve its goals, India, as the potential space power of the Third World, has had to draw upon the available resources of the world's leading space powers. It has, therefore, pursued a course of diversity in the search for space partners. In the process the United States made great contributions to the Indian space effort, particularly in such areas as communications, remote sensing, meteorology; and these contributions have been gratefully acknowledged.[49] But India also looked to Moscow for assistance, and the Soviet leaders have obliged.[50]

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[47] Nandakumar, P. Space Research in India. Indian & Foreign Review, vol. 15, Nov. 1, 1977:15–20, and House Science and Technology Committee, World-Wide Space Activities, 1977, p. 119. For other discussions of India's space organization, see, Jayaraman, K. S. India's March into Space. Indian & Foreign Review, vol. 16, Mar. 1, 1979:15–19, and Jayaraman, K. S. The Launching of Rohini Satellite: India Set for Further Advance in Space. Indian & Foreign Review, vol. 17, Aug. 14, 1980, pp. 9–11.

[48] Nandakumar, Space Research in India, p. 15.

[49] Perhaps one of the most important successes in U.S.-Indian space cooperation was the experimental program using the ATS–6 satellite for broadcasting television programs to some 5,000 Indian villages. Congressional hearings during 1976–80 contain repeated references, stressing the value to India and the general success of the program. In reviewing NASA's international program milestones for 1975, Arnold Frutkin referred to this experiment as "another landmark." Frutkin had visited many of the villages to observe the program in action. "It is an extraordinarily successful program with enormous implications of a complex kind," he said. Attendance at schools served by receivers had gone up some 30 percent; the enthusiasm of the villagers has continued "very high"—there was no "falling off and no indication that there is a novelty syndrome here." (House Science and Technology Committee, Hearings, 1977 NASA Authorization, 1976, vol. 1, pt. 2, p. 647.)

In his report the following year, Frutkin said that a systematic socio-economic evaluation of the Satellite Instructional Television Experiment program (SITE) which used the NASA ATS–6 satellite was not yet complete, "but preliminary findings appear most positive. The villages clearly want continuing service, and it appears there have been beneficial impacts on school attendance and progress, village health, farmer income, even the birth rate." Success of the program, he noted, had led the Indian Government to make interium provision for TV service to some 12,000 villages through ground relay stations. (The Indians built, designed, developed, manufactured, distributed and maintained the village receivers and prepared all the program material on farm improvement, family planning, village hygiene and school education.) "More important," Frutkin reported, "India is taking steps now to establish a follow-on domestic satellite system to operate in 1980." India began discussions with American firms and NASA for the potential purchase of the necessary spacecraft and launching services. (House Science and Technology Committee, Hearings, 1978 NASA Authorization, 1977, vol. 1, pt. 3, p. 72.)

In 1978, Mr. Norman Terrell, Director of International Affairs, NASA, reported that the SITE experiment "was a success and the Indian report shows that from the viewpoint of social and educational benefits there were important values in the experiment." Because of the experiment's success, the Indian Government, he said, decided to establish its own domestic communications satellite system. "They have contracted to launch it aboard the Shuttle in 1981," he said, "and the satellite will most likely be procured from a U.S. contractor." Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 3, pp. 928 and 950–951.

Landsat was another program that was well received in India. As P. Nandakumar, the Indian space specialist, wrote, "The Landsat imageries supplied by the U.S.A. are of great use to us." (Nandakumar, Space Research in India, p. 20.) Congressional hearings during the period under review record numerous instances of Landsat's success.

[50] In a review of Soviet-Indian space cooperation, Mikhail Chernyshov wrote of India's appreciation: "Indian scientists and specialists highly appreciate the scientific and technical assistance rendered by the Soviet Union, which, unlike some other countries, helps them accumulate this experience." (Chernyshov, Mikhail. Russian Report: Future Joint Soviet-Indian Space Adventure. Space World, May 1980, p. 23.)

SOVIET ROLE IN INDIA'S SPACE PROGRAM

India's satellites, Aryabhata and Bhaskara

The Soviet Union has been a major contributor to India's space effort. Foremost in this effort was Soviet technical assistance in building and in actually launching India's satellites, Aryabhata and Bhaskara.

On April 19, 1975, the Soviet Union launched India's first satellite Aryabhata. Designed purely for scientific experiments, the satellite was built by India, but the Soviets provided technical assistance and components such as solar cells, batteries, thermal paints, and tape recorders. Though the satellite was expected to perform solar and atmospheric studies for 6 months, the experiments had to be closed down after 5 days due to a power supply problem.[51]

By the terms of an agreement between ISRO and the Soviet Academy of Sciences, a second satellite in this series, Satellite for Earth Observation (SEO), called Bhaskara, was launched in the Soviet Union on June 7, 1979. The primary task of this satellite was to assess India's natural resources and conduct meteorological studies. Bhaskara used television cameras and microwave radiometer equipment designed and developed in India. According to Soviet sources, the satellite was built with Soviet scientific and technical assistance; Indian scientists took part in the launching pad tests of the satellite.[52] The first camera shots from aboard Bhaskara were received on May 17, 1980 at the Indian space research center in Bangalore.

The Soviet Union offered to launch India's Bhaskara 2 and 3, scheduled for mid-1981 and 1984 respectively. No charge is made for the launches. In return India pledges to share all the data it gathers from the satellites.[53]

Other aspects of Soviet cooperation summarized

Scattered throughout the sources on Indian space activities were the following references to other aspects of Soviet cooperation:

> Under an agreement with the Soviet Union's meteorological service, one M-100 rocket has been fired weekly, apparently since 1970, from the TERIS range for meteorological studies as part of a global program.[54]
>
> The Soviet Union and other members of Interkosmos, such as Czechoslovakia, Hungary, Poland, and the GDR, have provided the tracking coverage, laser equipment and their accessories for setting up the Satellite Tracking and Ranging Station (STARS) at Kavalur, Tamil Nadu.[55]
>
> In 1979, India cooperated with the Soviet Union in the Monsoon Experiment (Monex II); India received lunar samples from

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[51] House Science and Technology Committee, World-Wide Space Activities, 1977, pp. 119-120, and Velupillai, David. ISRO: India's Ambitious Space Agency. Flight International, vol. 117, June 28, 1980, p. 1466.

[52] Facts and Figures: Soviet Achievements in Space Exploration. International Affairs, vol. 7, July 1980:135-136. An Indian source noted that both satellites used "Soviet Union-supplied solar panels, batteries and thermal paints, but were otherwise almost completely of Indian manufacture."

[53] Velupillai, ISRO: India's Ambitious Space Agency, p. 1466.

[54] Nandakumar, Space Research in India, p. 20.

[55] Ibid.

the Soviet Union for analysis by its scientists; and an Indo-Soviet joint balloon experiment in gamma ray astronomy was scheduled for the end of 1979.[56]

In setting up TERIS, the Soviet Union's meteorological service along with NASA and CNES, provided support in the form of the equipment.[57]

Work on a multichannel tropospheric communications link between the Soviet Union and India entered its final stage in June 1980; under construction by Soviet and Indian scientists and specialists, the link was expected to become operational around November 1980; the Soviet Union provided the necessary radio and technical equipment for the station at Chari-i Sherf in India.[58] Finally, India accepted the Soviet invitation to nominate two candidates for cosmonaut training in preparation for a joint space flight in 1983.[59]

A MIXTURE OF INDEPENDENCE, DIVERSITY, AND COOPERATION

Soviet contributions to India's success in space

That space cooperation with the Soviet Union has paid off and accordingly has enabled India to pursue its space policy with some measure of success, there seems to be little doubt. Also aided substantially by the United States and the European space powers and, moreover, drawing upon its own formidable resources in scientific and technical manpower, India has indeed achieved much success in space, doing so, as one space observer put it, "on a shoestring."[60] Having been "fortunate to have excellent cooperation" with the world's space powers, as K. S. Jayaraman, an Indian space specialist, wrote, India, in his estimation, "has almost reached the stage of self-sufficiency in space technology,"[61] an established goal in its space policy. India has wisely emphasized the practical side of space applications, and accordingly has gained much from its efforts. Perhaps Jayaraman best summed up the importance of India's achievements internationally when he concluded:

> India has come a long way since it fired a toy rocket 15 years ago. Its experience is a lesson to other developing nations that space research need not be very expensive and that it can play a key role in economic and rural development.[62]

Or as Mohan Sundara Rajan, another India space observer, said in commenting on the "keen interest" of Third World countries in the coming Second United Nations Conference on the Peaceful Uses of Outer Space in 1982:

> What is wanted by the developing countries is basically an opportunity. India's young engineers have proved that given the opportunity, it is possible to leap-frog

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[56] Ibid.

[57] Jayaraman, India's March into Space, p. 19.

[58] Moscow Tass International Service in Russian, 1732 GMT, June 9, 1980, in FBIS Daily Report: Soviet Union, vol. 3, June 10, 1980, p. D7.

[59] Shirokov, V. Preparing for Flights. Pravda (Moscow), Oct. 9, 1981, p. 1, in FBIS Daily Report: Soviet Union, vol. 3, Oct. 15, 1981, p. D1.

[60] Mama, India's Space Program, p. 60.

[61] Jayaraman, India Set for Further Advance in Space, p. 11.

[62] Jayaraman, India's March into Space, p. 9. See also the concluding paragraph in Velupillai's article in which he stated that India's space program was "beginning to blossom and will soon bear fruit . . . gradually at first, but soon reaching the point where weather satellite pictures, improved communications and better resource management are commonplace." (Velupillai, ISRO: India's Ambitious Space Agency, p. 1470.)

into the Space Age even from bullock carts. As for cost, the entire investment from the early sixties, is less than the price of eight or ten jumbo jets.[63]

Thus the Soviets deserve some credit for their contributions to the Indian space effort; for the record of Soviet-Indian space cooperation suggests that there is some truth in the statement by Nikolay Novikov, deputy chairman of the Interkosmos Council, Soviet Academy of Sciences, when he said, in the words of Tass, "The decade of Soviet-Indian cooperation in space . . . has been rich in important developments." [64]

Soviet political motives in space cooperation

But Soviet motives have not been so wholly altruistic as they appear in their pronouncements on space cooperation with India. As noted at the beginning of this section, the Soviet Union pursues a much larger policy in the Third World, one designed to establish a symbiotic relationship between itself and the Third World and to foster accordingly the false idea of a shared political destiny. Since the mid-1950's, India has been the centerpiece of this policy, and space cooperation has been an integral part of it.

In pursuit of India's interests

Still, India has seemed thus far to have successfully kept something of a balance, not always a delicate one, in its commitment to nonalignment between East and West. Perceiving its own interests and pursuing its foreign policy accordingly, India has, for example, resisted Soviet pressures to conclude a security pact with Russia against China, a long time Soviet goal. And despite Soviet largesse in military and economic assistance, India has pursued its own interests and its own course in foreign policy, and indeed in space policy, seeming to establish a prudent mixture of independence, diversity, and cooperation.[65]

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[63] Rajan, Mohan Sundara. India in Space. India News, vol. 19, Sept. 29, 1980:4.

[64] Moscow Tass in English, 1029 GMT, June 11, 1980, in FBIS Daily Report: Soviet Union, vol. 3, June 12, 1980, p. D2.

[65] The depth and degree of the Soviet commitment to India are apparent in the economic aid and military assistance given to India over the years. During 1954-78, the Soviet Union extended a total of $2,282 million in economic credits and grants to India. For the same period the countries of Eastern Europe extended $455 million. During 1973-77, the value of Soviet arms transfers to India alone was placed at $1,100 million; arms transfers from Czechoslovakia were valued at $10 million, and from Poland $40 million. During 1955-78, 2,200 Indian military personnel were trained in the Soviet Union. In May 1980, the Soviet Union agreed to sell India $1.6 billion in weapons, the largest arms agreement ever concluded between the two countries. (House Foreign Affairs Committee, Soviet Policy and United States Response in Third World, p. 82.)

An example of Indian resistance to Soviet pressure is seen in the concluding comment by The Economist of June 16, 1979, in an article on Soviet-Indian relations in light of the visit of India's Prime Minister Morarji Desai to Moscow; "Russia is extremely keen to strengthen its links with India by offering sophisticated technology in strategic fields. Apart from the proposal for a joint manned space flight, it has offered nuclear submarines and a 1,000-megawatt nuclear power station. India has politely turned down these handsome gestures. What India does need is industry and an agreement for Soviet technical and financial aid for a $3 billion steel plant at Vishakapatnam was signed during Mr. Desai's visit to Moscow" (p. 51).

COOPERATION WITH OTHER NON-COMMUNIST COUNTRIES

MINIMAL SPACE RELATIONS

Judging from the extensive materials reviewed, Soviet bilateral cooperation with non-Communist countries, other than those discussed above, appears to have been minimal.

Sweden has had a limited program of space cooperation with the Soviets. In June 1975, a Swedish and Czechoslovak payload was lost in an unsuccessful mission. Subsequently, another Swedish experiment was flown aboard Interkosmos 16. Successful, this experiment involved linear polarization in solar ultraviolet radiation.[66]

In 1978, the Soviets offered to launch at least one ESA Marots maritime communications spacecraft as the Soviet Union's contribution toward setting up an operational system in the context of the Marisat program. The Soviet offer, described as an "unusual cooperative effort," was discussed in a major presentation of ESA to the American Institute of Aeronautics and Astronautics.[67]

SELF-SUFFICIENCY IN TRACKING

Perhaps one factor in reducing the range of Soviet space relations has been their virtual self-sufficiency in tracking. Having been able to accommodate a vast nationwide tracking system in their own country because of its size (2½ times that of the United States), the Soviets have had a broad base for space operations without going abroad. Efforts have been made, however, to put some tracking facilities in Africa and Cuba.[68]

But the Soviets have accepted the constraints on their space operations, and in addition to their own home base they have relied on some 11 tracking ships assigned to the Academy of Science. The most widely known of these ships are: *Kosmonavt Vladimir Komarov, Akademik Sergey Korolev, Kosmonavt Vladislav Volkov, Kosmonavt Pavel Belyayev, Kosmonavt Georgiy Dobrovolskiy,* and *Kosmonavt Viktor Patseyev.* Other unidentified tracking ships, associated with military missile tests, have been available to augment the Soviet tracking system.[69]

Self-sufficiency in tracking for the Soviets has the virtue of reducing the necessity of establishing arrangements with other nations to house tracking facilities. In contrast, the United States has had to maintain a worldwide tracking system.

ON FUTURE COOPERATION

Whether Soviet space relations with other non-Communist countries will expand can only be a matter of speculation. The appeal of space cooperation, however, cannot be minimized; for among the countries of the Third World, who like India have much to gain from the practical application of space technology to their development needs, space cooperation holds a special attraction.

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[66] House Science and Technology Committee, World-Wide Space Activities, 1977, p. 510.

[67] Covault, Craig. Soviets Offer to Launch Marots Vehicle. Aviation Week & Space Technology, vol. 108, Feb. 27, 1978:45. See also, Mar. 13, 1978:77.

[68] Sheldon, United States and Soviet Progress in Space, 1980, p. 22.

[69] Ibid., p. 23.

Illustrative of the potential appeal of space cooperation in the Third World is the apparent impact that Soviet space hero cosmonaut Shatalov made during his goodwill tour of the Philippine Islands in 1977. Filipino university students were particularly interested, he said, in the practical application of space technology in such areas as, the discovery of mineral resources, in the study of oceanography and fishing resources, and in developing early warning systems for detecting approaching typhoons—all matters of concern to the Philippines.

Against this background of real need Shatalov could and did make his sales-pitch for cooperation with the Soviet Union:

> I stressed time and again that the Soviet Union co-operates in space exploration with many countries and strives to expand international co-operation in this field. I found my Philippine hosts interested in that and generally in co-operation with the Soviet Union in other fields.[70]

COOPERATION IN THE UNITED NATIONS AND OTHER INTERNATIONAL ORGANIZATIONS

THE SOVIETS AND MULTILATERAL COOPERATION

The Soviets are committed to multilateral cooperation as well as bilateral cooperation.[71] This commitment, evident in a practical way from the above record, is evident also in published declarations.

Academician Fyodorov made this comprehensive statement of Soviet policy on space cooperation:

> International cooperation in all of these areas of outer space exploration and exploitation is gaining in scope and intensity. Its basic forms, as in other sciences, are exchange of research findings, cooperation in theoretical and laboratory research and, finally, joint space experimentation. It should be underlined at this point that space vehicle design, launching and operating require vast resources, and therefore cooperation in this area can yield the highest dividends.[72]

Sevastyanov and Ursul put it this way:

> Under present-day conditions, the most effective exploration of outer space and utilization of the achievements of cosmonautics are possible only through an extensive development of international cooperation and concerted effort by all the countries of the world. As is known, space exploration requires considerable allocations. Quite often many costly space projects are beyond the means of individual states and demand the cooperation of a number of countries. Since the flight trajectories of space vehicles pass over the territory of various countries, the need arises for such flights to be regulated by international law. All this determines the international character of space activities.
>
> The view has already been expressed in Soviet literature that in the near future major space projects will be carried out within the framework of the international division of labour. Any interested country could take part in the fulfillment of such projects and on the same equal footing share the results obtained with other countries.[73]

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[70] Interviews: A Cosmonaut Looks at the Philippines. New Times (Moscow), vol. 1, January 1978:23-24. For an explanation of Japan's poor record of space cooperation and the potentiality for cooperation in the future (a future from which the Soviets cannot be excluded), see, statement of Dr. Minoru Oda, chairman, Space Science Committee, University of Tokyo, House Science and Technology Committee, Hearings, International Space Activities, 1978, pp. 123-124. Dr. Oda explained Japan's isolationism and the gradual movement toward international cooperation and then said, "But we are only at the beginning and there will be more collaboration perhaps starting with these in science."

[71] For an earlier discussion of this aspect of Soviet space activities, see, Senate Aeronautical and Space Sciences Committee, Soviet Space Programs, 1971-75, pp. 127-128.

[72] Fyodorov, Use of Outer Space and Interests of Nations, p. 14.

[73] Sevastyanov and Ursul, Cosmonautics and Social Development, pp. 76-77.

Yet the Soviet approach to multilateral cooperation suffers from certain constraints, and the most important is military domination of the Soviet space program. No distinction is made between the military and civilian aspects of the program. And as DOD spokesmen persistently remind their listeners in congressional hearings, the military run, indeed dominate, the Soviet space program. This organizational arrangement severely restricts access by other nations. Moreover, the Soviet penchant toward secrecy and their traditional distrust of foreigners—both characteristics derived from excessive concern for security—fortify the institutional prejudices, skewing it against a free-and-easy, close-in type of cooperation.

The Soviet practice of maintaining complete control over flying experiments of other nations aboard their spacecraft reflects this uneasiness and acts as a constraint to cooperation. Other constraints are visible in such areas as space communications where the transmission of information can be highly politicized and where the principle of "freedom of information" is viewed from conflicting perspectives.[74]

Yet, there are forms of multilateral cooperation that do not require a close-in interrelationship. Such is the case in space meteorology.[75] And even in cases of flying experiments aboard Soviet spacecraft, as in Kosmos 936. American scientists acknowledged that absolute Soviet control over operations did not rule out a fruitful arrangement.

Forms of multilateral cooperation are, therefore, possible and under certain circumstances can flourish.

SOVIET COOPERATION IN THE UNITED NATIONS: A BRIEF COMMENTARY

In no institution has the Soviet commitment to space cooperation been more consistently reflected, particularly in the past decade, than in the United Nations.[76] Perhaps, Academician Fyodorov best summed up the Soviet perception of the growing role of the United Nations in international space relations when he wrote:

> The rapid development of a vast range of practical applications of space technology and a host of controversial technical and legal issues arising in the process demand, in our view, an enhancement of the coordinating role of the U.N. in this field.[77]

The Soviets have been major actors in the United Nations, and as a leading space power they have played a major role in the work of the Committee on the Peaceful Uses of Outer Space. Their role, at least in a quantitative sense, is reflected in the vast range of problems, listed by Kosolov, that have been on the committee's agenda:

> The United Nations and, more particularly, the General Assembly's Committee on the Peaceful Uses of Outer Space constitute the major international forum for

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[74] For a statement on the Soviet view with respect to television broadcasting via satellite, see, Kolosov, Space and International Law, pp. 60–61.

[75] See Fyodorov's explanation in, Use of Outer Space and Interests of Nations, pp. 15–16.

[76] For more detailed coverage of space activities relating to the United Nations, see, House Science and Technology Committee, World-Wide Space Activities, 1977, ch. 7, International Issues Concerning Space Cooperation, and appendix A, International Space Agreements. See also, U.S. Congress, Senate Committee on Commerce, Science, and Transportation. Agreement Governing the Activities of States on the Moon and Other Celestial Bodies. 96th Cong., 2d sess. Washington, U.S. Government Printing Office, 1980, pts. 1, 2, and 4 (committee print).

[77] Fyodorov, Use of Outer Space and Interests of Nations, p. 18.

> coordinating the political and legal aspects of international cooperation in the exploration of outer space. Among the questions on the Committee's agenda are: the elaboration of principles governing the use by states of artificial Earth satellites for direct television broadcasting (DBS); remote sensing of the Earth by satellites, including activities relating to the monitoring of pollution of the environment; the preparation of a draft treaty on the Moon; the definition of outer space and space activities; the staging of a second U.N. conference on the peaceful exploration and use of outer space; the use of space transport vehicles; and the technical aspects and appropriate safety measures relating to the use of nuclear power sources in outer space.
>
> Even this incomplete list of problems shows that the Committee faces big and complex tasks, which cannot be tackled in isolation from an entire set of present-day international issues. The success achieved in resolving these dramatic problems will be largely instrumental in the furtherance of international cooperation in the use of outer space.[78]

The Soviets have prided themselves on the part that they have played in managing, but not necessarily resolving, these problems. This pride was visible in the opening paragraph of a speech by Professor A. S. Pyradov, Soviet representative at the 24th session of the COPUOS, on June 22, 1981 when he said:

> Since the establishment of our Committee in 1959 enormous progress has been made by the space science throughout the world. During that period the Committee has fulfilled great and useful work on the organization of international co-operation in the exploration and peaceful uses of outer space and celestial bodies. The Committee actively participated in creation of the international space law, which has become one of the major branches of contemporary general international law. It can be stated that the conquest of space is being fulfilled within the strict legal framework, that makes it possible for the achievement of the space science to be enjoyed for the benefit of all states, the whole of mankind.[79]

Pyradov gave textual support for Soviet resolve to "achieve further progress" in promoting international space cooperation by quoting from Brezhnev's report to the 26th Party Congress in February 1981:

> Life requires fruitful co-operation of all the countries for solving the peaceful, constructive tasks facing every nation and all humanity. . . . there already exists a valid basis for the further extension of practical peaceful co-operation among states. And the need for it is increasingly apparent. It is enough to mention such problems, for example, as discovery and use of new sources of energy, provision of food for the world's growing population, preservation of all the riches of Nature and Earth and exploration of outer space and the depth of the World Ocean.[80]

For the Soviets, this affirmation of the principle of international cooperation, as Professor Pyradov said, demonstrates that cooperation in space is "one of the promising directions of the progress . . . of humanity."[81]

The United Nations, therefore, has been a major arena for the Soviets in pursuit of their political goals in space. On some issues, such as the Moon Treaty and direct satellite broadcasting, sharp differences have arisen; for the adversarial spirit that has permeated East-West relations has not appreciably diminished in the search for the peaceful uses of space. But on the other hand achievements have been made in recent years that probably never would have been contemplated early in the Space Age.[82]

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[78] Kolosov, Y., Legal and Political Aspects of Space Exploration. International Affairs (Moscow), vol. 3, March 1979:86.

[79] Union of Soviet Socialist Republics. Mission to the United Nations. Press Release No. 82, June 24, 1981, p. 1. The writer is grateful to Mrs. Eilene Galloway, the noted American authority on space law, for sending along this speech on the occasion of attending the 24th session of COPUOS.

[80] Ibid., p. 2.

[81] Ibid.

SOVIET COOPERATION WITH OTHER INTERNATIONAL ORGANIZATIONS

COSPAR

The Soviet Union carries on multilateral cooperation on space-related matters within international organizations other than those such as COPUOS and the WMO that are associated with the United Nations. Prominent among them are COSPAR, the International Telecommunications Union (ITU), and the IAF.

COSPAR, an affiliate of the International Council of Scientific Unions (ICSU), was established in October 1958 to continue the work of the International Geophysical Year (IGY). According to its charter directive, COSPAR's primary task is to,

> Provide the world scientific community with means whereby it may exploit the possibilities of satellites and space probes of all kinds for scientific purposes, and exchange the resulting data on a cooperative basis.[83]

Concerned only with basic research, not technological problems such as rocket propulsion or guidance and control systems, COSPAR is a catalyst for developing scientific goals to be achieved in space. It neither initiates nor approves individual investigations, and its objective is to maintain communication links within the international scientific community and encourage scientific cooperation in space research without regard to politics. Thirty-four countries and 12 scientific unions constitute the membership of COSPAR.[84]

The Soviet Union, along with its Interkosmos allies, is a member of COSPAR. The frequency of references in this study to COSPAR suggests in a general way active Soviet participation.[85]

The ITU

The ITU, formed in 1932 and affiliated with the United Nations, is an important international agency particularly in the present era of expanding space communications. It is important because of its responsibility for allocating the radio frequency spectrum. The Soviet Union and the United States use about 50 percent of the world's broadcasting spectrum. Pressure from the less developed countries (LDC's) for greater access to the already crowded spectrum suggests not only a long-term international problem but also the necessity, indeed the inevitability, of extensive Soviet international cooperation at international conferences empowered to reassign radio frequencies.[86]

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[82] Some of the landmark achievements were: The Outer Space Treaty of 1967; the Astronaut Rescue and Return Agreement of 1968; the Convention on International Liability for Damage Caused by Space Objects of 1973; the Convention on Registration of Objects Launched Into Outer Space of 1976. (House Science and Technology Committee, World-Wide Space Activities, 1977, pp. 561-562.); and the Moon Treaty was opened for signature on Dec. 18, 1979.

[83] House Science and Technology Committee, World-Wide Space Activities, 1977, p. 555.

[84] Ibid., p. 556.

[85] Ibid., pp. 92 and 555. Fyodorov, for example, made this general reference to COSPAR: "Cooperation in space research is governed by a variety of bilateral and multilateral agreements and coordinated by special international scientific associations, including such important ones as the Committee on Space Research and the International Astronautical Federation." (Fyodorov, Use of Outer Space and Interests of Nations, p. 15.)

[86] Hart, Thomas A., Jr. A Review of WARC-79 and Its Implications for the Development of Satellite Communications Services. Communications and Law, vol. 2, Spring 1980:22-24.

Thomas A. Hart, Jr., vice president of the National Institute for Communications and Education and a specialist on the legal aspects of communications, suggests the dimension of this problem when he wrote in a review of the World Administrative Radio Conference of 1979:

> The communications gap between the advanced and developing nations results not only from limited spectrum resources, but also from a lack of money and trained telecommunications personnel to plan, implement, and operate communications systems. Fearful that the gap will widen even faster with the introduction of new technologies, particularly satellite broadcasting, emerging nations are calling for increased technical assistance and procedures to assure them 'equitable access' to the frequency spectrum and the geostationary orbit.[87]

The issue of the radio spectrum extends beyond strictly telecommunications to the much larger Third World concern for the management and dissemination of information. In staking out its claim to a larger role in international communications, the Third World has called for the establishment of what it calls the "New World Information Order" which has become the rallying point for its case against what it terms the Western monopoly over the dissemination of international information. The Soviet Union which has well defined political goals in the Third World has sought to exploit this issue, to the detriment of the United States and the West.

The combination of this issue with the specific task of managing the communications radio spectrum suggests the enormity and complexity of this problem and emphasizes the point being made here; namely, that the Soviet Union will be a major participant in future international discussions on the communications issue and that solutions are imperative, requiring cooperation.[88]

The IAF

The IAF, founded in 1950, is a nongovernmental, scientific, nonprofit organization of national societies and institutions that are interested in rocketry, astronautics, and in the peaceful uses of outer space.[89] It meets in Congress annually to exchange views and information on space—"the most important reason for having an IAF," according to James J. Harford, executive secretary of the American Institute of Aeronautics and Astronautics. The Soviet Union is an active member of the IAF. Soviet space authorities, like Academician Leonid Sedov, have been top ranking officials. In the 1978 meeting at Dubrovnik, Yugoslavia, Sedov was elected vice president for the 22d consecutive year.[90]

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[87] Ibid., p. 24. Dr. William Schneider, Associate Administrator for Space Tracking and Data Systems, NASA, underscored the importance of the General World Administrative Radio Conference when he testified: "The most far-reaching event in communications was the recently concluded General World Administrative Radio Conference." According to Schneider, "It is fair to state, I believe, that the results of this conference will impact every person on Earth for the next 20 years in one way or another. It is also fair to state that the degree of impact is directly related to technology level." (Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1981, 1980, pt. 2, p. 1246. For a more detailed statement by Dr. Schneider, see p. 1264.)TheemsissueASAof

[88] According to FCC Foreign Affairs Chief I. Kalmann Schaefer, "there are 21 major international radio conferences scheduled over the next 6 years. One of the conferences, a 1984 meeting designed to play for outer space communications service, will impact seriously on the communications service and will be offered in the late 1980's." (Ibid., pp. 37–38.)

For a discussion of the Third World's "New World Information Order", see, Engel, Victoria L. Freedom of Information in the Third World: Soviet Perspectives and Initiative in UNESCO. Library of Congress, Congressional Research Service, Aug. 7, 1981, 22 p. (Multilith: Report No. 81–160 S). Miss Engel concluded her study with this observation:

"The Soviet Union could gain certain objectives in the Third World through a successful campaign for international sanction of regulation of the mass media. But the success of Soviet-backed plans for control of the media is by no means assured. Discussions and debate on the New World Information Order and the recommendations of the MacBride Commission Report will continue to take place within a number of UNESCO meetings, including the meetings of the Intergovernmental Council on the IPDC. The results of this debate and attention will be considered during the 1983 regular session of the UNESCO General Conference. It is possible that by pursuing aid to Third World media and by emphasizing unified opposition to government regulation of the press, as they did at Talloires, free press advocates can counter efforts within UNESCO to control the international flow of information. For the present, any substantive compromise between the West and the Soviet Union on this issue would seem to be highly unlikely."

Fairly comprehensive reports on IAF congresses by Harford have been published routinely in the journal, Aeronautics & Astronautics.[91] A review of the reports on the 29th Congress at Dubrovnik and the 30th in Munich give some indication of the extent of Soviet participation. While it would be difficult to generalize from these reports, still they contain both critical and favorable commentaries on Soviet and East European participation.[92]

The presence and performance of the cosmonauts seemed to win approval, but his was not the case in other areas of space.

Speaking generally of the Dubrovnik Congress, Harford quoted James Martin of Martin Marietta, the former Viking Project director in NASA. The point at issue was the weak Soviet contributions to the two sessions on unmanned solar system exploration. "As usual," Martin said, "the U.S.S.R. presented *no* data or information on their spacecraft, even though they have two probes en route to Venus. . . ." "A large group of U.S.S.R. participants," he continued, "did listen carefully to other papers, took notes, and tape-recorded some sessions." Harford concluded:

> In short, the mostly take and little give of the Soviets was as evident in Dubrovnik as last year in Prague, and before that in Anaheim, Lisbon, Amsterdam, and even their own Baku in 1973.[93]

At the Munich Congress there were a few good Russian papers, Harford noted, but most of the top technical performers were not present. Harford gave this critical assessment:

> The buzzing of the cosmonauts raised hopes that the Soviet technical program, in contrast to that publicity tour de force, would be more substantive than last year's poor showing in Dubrovnik. Alas, it was even worse this time.
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> Although there were 61 Soviet papers listed in the program, at least 16 were scratched (this reporter tracked virtually every session, having been accused of un-

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[89] House Science and Technology Committee, World-Wide Space Activities, 1977, pp. 558–559.

[90] Harford, James J. 29th IAF Congress, Dubrovnik, Yugoslavia: A Rush of Space Programs. Aeronautics & Astronautics, vol. 17, January 1979: 57. On this occasion Sedov wanted to defer to another Soviet colleague, but "the General Assembly elected him by acclamation," according to Harford's report. Eberhard Hollax, an East German, was also elected to the Bureau as a vice president.

[91] Harford wrote about the Dubrovnik meeting: "Voluminous notes compiled by a 27-person team of AIAA members (see box) covering the 36 sessions and more than 300 papers, plus numerous committee and business meetings, give us reports of progress, but also plenty of disappointment." (Ibid., p. 56.)

[92] The quotation in the preceding footnote continued with this example of what was meant by "plenty of disappointment": ". . . the reentry session was thin and half the Russian authors not there; bioastronautics sessions, usually interesting at IAF, not up to standard, and three of its seven papers were not given, including the Soviet paper on cabin toxic gas contaminants, and a U.S. paper on the Shuttle extravehicular mobility unit." On the other hand, Harford reported: "H. J. Fischer gave an excellent slide and film illustrated report on the East German program. . . . He said they had been working with the Soviet Union since 1967, with their scientists and engineers getting their education in the Soviet Union. It was impressive to note the high technology in the East German effort, including computerized printed circuits and sophisticated ground equipment" (p. 63).

[93] Harford, 29th IAF Congress, Dubrovnik, pp. 56–57.

supported criticism of last year's Soviet performance). And with the entire Soviet delegation consisting of 26 people, many surrogate authors droned others' papers.[94]

Harford acknowledged, however, that there were "a few very good Russian papers" delivered at the Congress.[95]

Though it is not possible to strike a balance even on the basis of Harford's reports of the Dubrovnik and Munich Congresses, still the point being made here is simply that the Soviets do participate in the IAF, notwithstanding the shortcomings in their performances that do not always measure up to the expectations of Western observers. At Dubrovnik, the Soviets had, for example, 71 delegates (the U.S. 89; Yugoslavia 115; France 97; West Germany 89; Italy 22; U.K. 17; Japan 15; and the Netherlands 20). Thirty countries were represented in all, in addition to the United Nations.[96] Moreover, interaction does occur not only among the assembled delegates but with members of COSPAR and the United Nations.[97] And such interaction can be a positive sign of the Soviet willingness to cooperate in space, though that cooperation would probably be restricted to limits that they themselves define or would be otherwise agreeable to them.

SPACE COOPERATION: SOME GENERALIZATIONS

COMMITMENT TO COOPERATION

Soviet space cooperation during 1976–80 suggests generalizations consistent with those recorded in the previous study: The Soviets are committed to and maintain a positive attitude toward space cooperation.[98] The record of bilateral and multilateral cooperation, however uneven, supports this judgment.

Success on the magnitude of the ASTP mission was not matched in Soviet-American space relations, but some progress was made in establishing a basis for future space cooperation. Despite increased tensions in political relations, satisfying forms of cooperation, as in the case of Kosmos 936 and 1129, did take place; others were planned.[99] In space cooperation with their East European allies

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[94] Harford, James J. 30th International Astronautical Federation Congress, Munich, September 16–22: Cosmopolitan Space in a Transitional Mood. Astronautics & Aeronautics, vol. 17, November 1979: 45.

[95] Ibid., p. 46.

[96] Harford, 29th IAF Congress, Dubrovnik, p. 64.

[97] Jean Francois Denisse, President of COSPAR, posed an "interesting challenge to the IAF General Assembly," Harford reported. Denisse described the restructuring of COSPAR and announced plans to meet every 2 years, starting in 1980, rather than annually. He suggested that there may be opportunities for cosponsored conferences between COSPAR and IAF. COSPAR was scheduled to meet in India in 1979 and Hungary in 1980. Academician Petrov followed Denisse immediately with the suggestion that after 1980 the IAF consider alternating its Congresses with COSPAR and in the intervening period conduct smaller symposia. Petrov asked that the IAF Bureau consider that issue very seriously. (Ibid. p. 65).

Harford's report contained an extensive commentary on the role of Lubos Perek, the U.N. representative at the IAF Congresses. Among other things, Perek thanked the IAF on behalf of the United Nations for its study on the detection and monitoring of pollution through satellites. He also expressed the hope that the IAF would play an important role in preparing for the Conference on the Peaceful Uses of Outer Space being planned by the United Nations for the period 1981–83. (Ibid., p. 64.)

[98] See, Senate Aeronautical and Space Sciences Committee, Soviet Space Programs, 1971–75, pp. 129–133.

[99] Given the diversity and complexity of Soviet-American space cooperation, it would be difficult to evaluate precisely the degree to which the United States has profited scientifically and technologically from these arrangements. This report reveals certain instances where the United States had benefited. This issue did not arise in the literature reviewed. However, the

Continued

and other Communist states, along with France and India, the Soviets registered many successes. And while the flavor of politics and propaganda more often than not permeated their purposes and performance, still the fact remains that they had made both scientific and political achievements.

In brief, the Soviets value space cooperation at least on a selective basis.

FACTORS FAVORABLE TO SPACE COOPERATION

Politics determine the degree of space cooperation: In times of easing tensions, it flourishes; in times of stress, it languishes. Agreement had been reached and planning underway for Soviet-American cooperation in the post-ASTP period. The downturn in political relations through 1977 and 1978, caused by the human rights issue, the establishment of U.S. diplomatic relations with China, and delays in concluding SALT II and accelerated by the Soviet invasion of Afghanistan in December 1979, closed down virtually all programs in bilateral space cooperation. Space relations followed political relations into a deep freeze.

Yet under certain conditions space cooperation is imperative, whatever the state of political relations. Interdependence, a bond of mutual self-interest among nations and a dominant tendency in the modern world, imposes this necessity. Hence cooperation in the WMO and ITU has the virtue of necessity. The U.S. decision to continue the SARSAT experiment with the Soviets was based on similar necessity, self-interest. And the conquest of space itself is beyond the powers of any one nation: Some division of labor, as the Soviets have said, is needed and that occurs in a mode of international cooperation.

The economics of space exploration also encourage space cooperation. This is the rationale for the Soviet belief in a division of labor in space. With rising costs in an era of expanding horizons in space, economic factors enter in to counsel sharing the burden. Economics was the underlying motive for the flight of U.S. life science experiments aboard the Soviet biosatellites—space exploration at a "cut-rate," as one observer said. And the same applies to the Third World: India, a developing country with very limited resources, built its space program "on a shoe string" through space cooperation with the major space powers.

The appeal of space to the Third World provides another stimulus to cooperation. Space applications have progressed with the advance of space exploration. Landsat, SITE, and GARP have become symbols, attracting the attention of the Third World with their message of what space can do for them. India has become the pacesetter for the Third World, and through cooperation it has proved the value of space applications to the needs of development.

Politics provides another incentive for space cooperation. As an instrument of political influence, space cooperation has proven its worth. In the heyday of detente both Soviet and American leaders

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issue was vigorously debated at the time of the ASTP mission in 1975. Qualified space specialists argued that in this instance the United States was giving more than it was receiving. For a discussion of both points of view, see, Senate Aeronautical and Space Sciences Committee, Soviet Space Programs, 1971-75, pp. 114-120.

strongly supported space cooperation as one of many means for solidifying the new relationship. Far-reaching agreements on space cooperation along with SALT I were signed at the Nixon-Brezhnev summit in May 1972, generally regarded as opening the era of detente.

Soviet cooperative programs with its East European allies, France, and India were partly based upon political principle: With Eastern Europe, to accelerate bloc integration; with France, to encourage division in the West; and with India, to advance its Third World policy.

American cooperative programs have also had their political ingredient: With Moscow, to solidify detente; with the Third World, to spread its influence; and with China, to play off Beijing against Moscow. The same can be said for France and India who "worked both sides of the street" in space cooperation with the United States and the Soviet Union to advance their policy of independence and diversity.

The objective in all cases, admitting such certain altruistic motives as advancing the cause of science and humanity, was to expand political influence. Space cooperation is not likely, therefore, to lose its appeal as a useful mechanism in international politics.

Finally, space cooperation allows lesser nations to participate in one of the most dramatic undertakings of the 20th century, space exploration. Through cooperation these nations are able to benefit not only from the practical applications of space but from the prestige to be accrued from identification with a great space power. So long as space exploration holds this appeal it will no doubt provide an important incentive to cooperation.

DETERRENTS TO SPACE COOPERATION

Deterrents to space cooperation can be formidable. Foremost among them is a hardening of political relations, a point well demonstrated in this study. Militarization of space is also a barrier to cooperation. Development of an ASAT system by both sides and Soviet criticism of the military aspects of the Space Shuttle, for example, appear to have contributed to those larger transcending political factors in adversely affecting Soviet-American space relations.

Excessive competition, particularly on the scale of the 1960's, works against the spirit of cooperation. Awareness of the inequity of scientific exchanges including those in the field of space science has drawn criticism from the American scientific community. This belief tends to reduce the appeal of cooperation.

And finally, cutbacks in space programs can have a detrimental effect on cooperation. Reductions in the NASA budget by the Reagan administration resulted in a retrenchment of U.S. cooperation in Western Europe. Similarly, growing problems in an already hard-pressed Soviet economy could bring on retrenchment in their space programs and accordingly impact upon space cooperation. (Conversely, it could be argued that retrenchment by both could lead to more cooperation in order to achieve goals at less cost.)

Future Prospects for Space Cooperation

A single dominating generalization emerges from this review of Soviet space cooperation: The Soviets are in space to stay and space cooperation is an essential and continuing part of their space policy. Bilateral cooperative programs with France and India are on stream; multilateral cooperation through the United Nations and other international organizations have long become established realities. In brief, a certain permanency has set in, institutionalizing the Soviet role in space and insuring favorable prospects for space cooperation in the future.

Whether Soviet-American space relations will improve depends upon conditions at the political level. Detente has proved to be perishable, and whether a satisfactory ongoing relationship can be established, one in which space cooperation can flourish, remains an open question. Serious foreign policy problems, particularly in arms control, continue to plague the relationship. Taking into account the international realities of 1980 and 1981 and the seemingly diminishing American commitment to space exploration, it is difficult to find much encouragement for seeing better times ahead, at least in the short term.[100]

Yet, space cooperation, as a fixed principle in contemporary international life, has intrinsic value of its own. Rooted in the scientific-technological revolution, it deals with issues generated by this revolution, providing the means for composing differences and satisfying vital interests in an area common to the concerns of all nations. In an interdependent world, cooperation is a tool serving the interests of all. It has a future, whatever the state of Soviet-American relations, but a future whose full potentialities can only be realized in a climate of reasonable peace and harmony.

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[100] With respect to the cutbacks in space, The Christian Science Monitor of Nov. 16, 1981 (p. 24) restated its concern in an editorial entitled, "Space: The Larger Outreach," acclaiming the second voyage of the Columbia Space Shuttle. The Monitor argued that along with putting astronauts into Earth orbit to perform useful tests, "the larger outreach in continued exploration of our solar system should not be neglected. This provides the knowledge on which the next generation's space achievements will be based, as well as giving us a valuable new perspective on our planet Earth today." "Yet, even as two new Soviet probes are speeding toward the planet Venus," the editorial continued, "the United States' space science program is being forced into dangerous decline by shortsighted budget cuts." These cuts "go beyond fiscal prudence," it said, at a time when Federal spending must be cut back. And the editorial warned, "They seem to presage a stifling of U.S. scientific space exploration." The Monitor reported "talk within the administration" of terminating the Voyager spacecraft program "before it can give humanity its first close look at the Planet Uranus—and of scrapping the Deep Space Tracking Network of ground stations that make communication with distant spacecraft possible." The Monitor noted the "great effort" and "great expense" the United States had expended in building up a capacity for scientific space exploration "that is as magnificent and as valuable as the manned spaceflight capacity the shuttle represents." And it issued this warning in conclusion: "To throw this away for short-range budgetary reasons or for lack of vision on the part of some members of President Reagan's administration would be a foolish waste."

Chapter 4

Administration of the Soviet Space Program*

INTRODUCTION

The aim of this chapter is to determine the organizational and administrative structure of the Soviet space program on the basis of the open literature. An effort is made to describe key organizations and groups involved in the program and to assess their interrelationship. The purpose is to discover where decisions on space originate and to find the channels through which they pass to the operational level.

Many of the conclusions remain speculative. Soviet secrecy is an obstacle to understanding many facets of that country's development. Areas such as the space program with any strategic implications or which are deemed sensitive are covered by all-pervasive secrecy. Soviet officials regard both the civilian and military aspects of their space program as highly sensitive. They have never released an organizational chart of the program. Thorough government censorship extends to all areas related to the organization and administration of the program. The result is that very little information on organization can be gleaned from the available Soviet literature. The open Western literature does not reveal a great deal more on the Soviet space organization. The problem of scarce information has been coupled in recent years with an apparent decline in interest in the West. The effort here is to try to piece together the fragments of information on the organization and administration of the programs.

LEADERSHIP INTEREST IN SPACE

The impressive results achieved consistently over the years by the Soviet space effort support the assumption that it is organized along the lines of the Soviet defense effort, possibly even as an integral part of that organization. It is only in the defense sector that the Soviet system has been able to achieve similar successes, without the glaring inefficiencies and chronic shortfalls so common to most sectors of the Soviet economy. That the necessary resources have continued to flow to make the space program function so successfully in a period of economic hardship is an indication of the leadership's commitment to that program.

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*Prepared by Francis T. Miko, Specialist in Soviet Affairs, Foreign Affairs and National Defense Divison, CRS. This section is a revised and updated version of a study prepared for the previous volume in this series: Soviet Space Programs, 1971-75, vol. II, ch. II, Organization and Administration of the Soviet Space Program, Aug. 30, 1976. Prepared for the Committee on Aeronautical and Space Sciences, U.S. Senate.

This top level commitment to space activities is underlined by the personal involvement of the Soviet leadership in space decisionmaking. Ultimate responsibility for the program has rested with the nation's ruling Politburo.

One member of the Politburo has primary responsibility for overseeing space affairs. Soviet leaders in their public statements consistently reaffirm their dedication to the space program.

A number of reasons may be surmised for the interest of Soviet leaders in space. They clearly recognize the military benefits and application of space research. Undoubtedly, they are aware of scientific technological payoffs in other areas. But they also seem to recognize and seek to exploit the political benefits derived from the space program.

Space achievements have a domestic political utility. They provide a means of generating public support by evoking the national pride of the Russian people in an endeavor clearly associated with the efforts of the party leadership. At the same time, substantial international benefits are also accrued from the space effort. Space successes enhance the international prestige of the Soviet Union as a leader in the most advanced fields of science and technology. Considerable international good will may also be generated by the highly visible involvement of foreign countries in joint space ventures. The inclusion of foreign cosmonauts in recent Soviet manned space flights have provided the image of a Soviet Union willing to share the "glory" and tangible benefits of space exploration with other countries. The political importance attached to this cooperation was stressed by Soviet President Brezhnev in his only reference to space in his opening speech to the 26th Soviet Communist Party Congress in February 1981:

> The field of our cooperation embraces more and more new spheres. An example of this is the Intercosmos program. The cosmonauts of the fraternal countries are working not only for science and for the national economy; they are also carrying out a political mission of immense importance.[1]

The Soviet space program is known to be a very large undertaking, employing several hundred thousand people, directly in the space program or in space related activities.[2] Such a massive organization would appear to require a high degree of coordination. However, it cannot necessarily be concluded that Soviet space administration is a rational, streamlined decisionmaking mechanism. In an earlier study of the program, in fact, Leonard N. Beck found the opposite in some areas, namely, administrative anarchy.[3]

Western observers have occasionally wondered how the program can function effectively in view of the overlapping jurisdictions between party and government, the participation of a myriad of institutions with no clear hierarchical relationship, and differences that exist everywhere between formal organizational structures and the loose informal working structures. Yet the results show that while the space organization may not function with optimum efficiency, it at least functions reasonably well. Two aspects of the Soviet governmental system may help to explain the success of the space program.

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[1] U.S. Foreign Broadcast Information Service. Daily Report: Soviet Union, vol. III, No. 36, supp. 1, Feb. 24, 1981, p. 6.

[2] Sheldon, Charles. United States and Soviet Progress in Space: Summary Data Through 1974 and a Forward Look. Washington, U.S. Library of Congress, Jan. 13, 1975, p. 21 (Congressional Research Service report No. 75-18 SP).

[3] U.S. Congress. Senate Committee on Aeronautical and Space Sciences. Soviet Space Programs, 1962-65; Goals and Purposes, Achievements, Plans, and International Implications. Staff report. Washington, U.S. Government Printing Office, 1966, p. 158.

The first such factor relates to the multiple responsibilities assigned to leading individuals. Where there is no clear link between organizations involved in the same program, a link may often be found in the person of their leadership. When two seemingly unrelated organizations are headed by the same individuals, informal coordination becomes easier.

The second such factor is what Leon Trilling in an earlier congressional study calls the principle of single responsibility operating throughout the Soviet system. Where there is no clear institutional responsibility, there often exists, formally or informally, a leader who will be held accountable for the success or failure of the program at any level.[4] This factor of single responsibility would seem to imply a fairly strict chain of command operating in the Soviet space organization.

ROLE OF THE COMMUNIST PARTY

The Communist Party of the Soviet Union is the dominant force in all spheres of Soviet life. While formally outside the government structure, the party exercises control, not only from the top but at all levels, through a centralized hierarchical organization that parallels the government and social structure at all levels down to local enterprises and institutions. The Party Congress which meets at irregular intervals, every few years, is formally the highest party organ. However, in practice the Congress has very little power and serves chiefly as a forum in which the leadership announces the launching of major policies.

As in other areas of Soviet policy, the Communist Party asserts its leadership over the space program. Top level decisions on space are probably made in the Politburo. Control over implementation of the decisions is the responsibility of the appropriate departments in the Central Committee. Soviet leader Brezhnev underscored the leading role of the party in science in a speech marking the 250th anniversary of the Soviet Academy of Sciences. He said:

> . . . Comrades, in the future you will have to work even more, more persistently and more effectively. We have no intention of dictating to you the details of research topics and the ways and means of research—that is a matter for the scientists themselves. But the main directions of the development of science, the main tasks that life poses, will be determined jointly.[5]

THE POLITBURO

The Politburo, together with the Secretariat of the party, exercises supreme power in the Soviet Union. Because of overlapping membership in these two highest bodies, their activities are well coordinated.[6] The Politburo presently has 13 full (voting) members and 8 candidate (nonvoting) members. The Politburo selects and removes its own members and those of the Secretariat, even though formal authority for this function rests with the Central Committee. The Politburo establishes all major policy guidelines and acts as the final arbiter among the competing interest groups in the Soviet Union.

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[4] U.S. Congress. Senate Committee on Aeronautical and Space Sciences. Soviet Space Programs: Organization, Plans, Goals, and International Implications. Staff report. Washington, U.S. Government Printing Office, 1962, p. 62.

[5] Academy of Sciences' 250th Birthday. Speech by L. I. Brezhnev. Current Digest for the Soviet Press, vol. 27, Oct. 29, 1975: 3.

The power structure within the Politburo has varied over the years. Under Joseph Stalin there was genuine one-man dictatorship, and the Politburo itself, became a virtual rubber stamp body. Since Stalin's death, there have been differing degrees of collective leadership. Both Nikita Khrushchev and Leonid Brezhnev were able to carve out dominant positions for themselves, but neither has been able to achieve absolute authority.

The Politburo in its capacity as the highest policymaking body in the Soviet Union is responsible for establishing goals and priorities, setting up the organizational framework and funding of the space program. It presumably seeks the advice of experts in the field before arriving at decisions.

The main directions of party policy on space can be publicized in a variety of ways. A platform sometimes used to launch major programs is the Party Congress, held at irregular intervals. At the 24th Congress of the CPSU, convened in 1971, for example, directives were issued to organize scientific work in outer space "in the interest of development of long-distance telegraph and telephone communications, television, weather forecasting, the study of natural resources, geographic research, et cetera, with the help of automatic and piloted spacecraft." [7] The functions of the party Congresses for the most part do not include the establishment of policy. They serve generally as a forum for unveiling policies that have already been decided by the leadership.

Final responsibility on space matters within the Politburo rests with the de facto Soviet leader. The degree of the Soviet leader's personal involvement in space decisions has probably varied over the years.

Observers have pointed out that at the time of the launching of the first Soviet Sputnik in 1957, Soviet Premier Nikita Khrushchev may not have immediately grasped the full political significance of the achievement, although he certainly already supported space research. Upon the successful completion of the Sputnik mission, Khrushchev's initial statements seemed to lack a great degree of enthusiasm. A few weeks later Khruschev's tone changed. He heaped praise on the individuals who accomplished the feat; he was boastful of Soviet leadership in the space field; and he took personal credit for the success of the Soviet space program. He was probably responding to the Western reaction of amazement and disbelief.[8] Khrushchev's level of personal participation in decisionmaking on space may have grown after his initial lesson in the propaganda value of space accomplishments. At the awards ceremony following Gagarin's successful mission as the first man in space in 1961, Khrushchev emphasized his personal role in the Soviet space program. He was presented the first and highest medal of honor for the successful flight.

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[6] Currently, there are 4 members of the 10-man Secretariat who are also members of the Politburo. They are: General Secretary L. I. Brezhnev, A. P. Kirilenko, M. A. Suslov, K. V. Chernenko, and M. S. Gorbachev.

[7] Sevastanov, V., and Y. Faddeyev. Soviet Cosmonautics and Scientific and Technical Progress. Space World, vol. 1, September 1972: 21.

[8] For an account of Khrushchev's reactions, see Daniloff, Nicholas. The Kremlin and the Cosmos. New York, Alfred A. Knopf, 1972, p. 66.

Also among those most prominently honored was Leonid Brezhnev, then the Soviet President, who may have had some responsibility in the administration of the space program within the Politburo.[9] Nikita Khrushchev allegedly took a very active part in formulating space policy decisions in 1963, when it was reportedly decided to accelerate the program in response to American successes.[10]

Following Khrushchev's ouster from the Politburo in 1964, his successor Leonid Brezhnev initially appeared to be moving in the direction of scaling-down or deemphasizing the Soviet space program. In his statement welcoming back cosmonaut Komarov and his crew from their successful Voskhod flight, Brezhnev said in an apparent criticism of his predecessor and of the United States:

> We are pleased of course, that our country is ahead in the exploration of space. But we Soviet people do not regard our space exploration as some kind of race. The spirit of reckless gambling in the great and serious matter of exploring and mastering space is deeply alien to us.[11]

According to American intelligence estimates, the person within the Politburo today with primary responsibility for space matters is member Dimitriy F. Ustinov.[12] The main thrust of the Soviet space program is apparent by the fact that Ustinov's other primary party duties are in the areas of defense and foreign military aid and support.

Ustinov is a graduate of the Professional Technical School and the Leningrad Military Mechanical Institute. He has been a full member of the Politburo since 1976, a candidate member since 1965 and a member of the Central Committee since 1952. He has served in the government as a Deputy Chairman of the Council of Ministers, as Minister of Defense Industries, and now Minister of Defense. Earlier he held senior positions in research institutes and directed the "Bolshevik" plant in the armaments sector.[13]

While primary duties are assigned to individual Politburo members probably on the basis of background, interests, and prestige, each member of the ruling body shares responsibilities in all areas. More intensive participation in decisions on space could be expected from those Politburo members who have primary decisionmaking responsibilities in related areas.

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[9] Ibid., p. 74. See also, Dornberg, John. Brezhnev: The Mask of Power. New York, Basic Books, Inc., p. 163.

[10] Oberg, James E. The Voskhod Programme: Khrushchev's Folly. Spaceflight, vol. 16, April 1974: 147.

[11] Dornberg, John. Brezhnev: The Mask of Power, p. 186.

[12] U.S. Central Intelligence Agency. Reference Aid: CPSU Politburo and Secretariat: Positions and Responsibilities. February 1980. (CR80-10001).

[13] Crowley, Edward L., et al., eds. Prominent Personalities in the U.S.S.R.: A Bibliographical Directory. Compiled by the Institute for the Study of the U.S.S.R. Metuchen, N.J., Scarecrow Press, 1968, p. 652.

THE CENTRAL COMMITTEE

The Central Committee is elected by the delegates to the Party Congress to function between congresses and act as the highest permanent party institution. Its membership (241 full members and 155 candidate members) is still too large for effective decisionmaking. One of its major functions is to elect the Politburo and Secretariat, which are the real top decisionmaking bodies in the Soviet Union. It also ratifies Politburo decisions. Central Committee election of Politburo members and ratification of decisions are still primarily a pro forma function. In most instances, approval of Politburo decisions and changes is automatic and unanimous. Nevertheless, the Central Committee is significant in that its membership for the most part represents the political elite of the Soviet Union and it exercises control over policy implementation.

The Central Committee is divided into departments which for the most part parallel the government structure at the ministry level. These departments have oversight duties over the corresponding ministries in the government. The departments also provide information to the Politburo.

It is difficult to name the Central Committee departments most closely involved with the space program, as all have not been fully identified. The departments handling science and educational institutions (headed by Sergei P. Trapeznikov) and defense industries (headed by Ivan D. Serbin) probably have a role in the oversight of the space program. The Central Committee as a body is reported to have conducted intensive reviews after Soviet space setbacks such as Salyut 1 and Salyut 2 in 1973.[14]

OTHER PARTY UNITS

From the Central Committee down, there is a vast network of party organizations which assures the Communist Party of control over Soviet society. These organizations are to be found at the Union Republic, district and local levels. Close to 500,000 primary party cells are at the bottom of the hierarchy. These are established in individual residential neighborhoods, factories, army units, schools, research institutions, and anywhere that there are three or more Communist Party members.

At the lower levels, the Communist Party also has the capability to perform a "watchdog" function over space affairs. Basic party units are present at research institutions, in the Soviet Academy of Sciences and its branches, in the relevant military sections and within the industries doing space work. While the main task of these units is probably the ideological training of the workers, they would seem to have other potential control capabilities and could provide a direct channel between the Central Committee and the individual institutions.

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[14] White, Sarah, and Grigori Tokati. Green Light for Soviet Space? New Scientist, vol. 65, February 1975: 439.

ROLE OF THE GOVERNMENT

In principle, the Soviet Government is completely separate from the Communist Party apparatus. In fact, once again due to the phenomenon of overlapping membership, the government leadership consists entirely of party members, and many key government officials also hold major positions within the party hierarchy. The Soviet Government has no independent authority, but is the mechanism through which party policies are implemented.

The Supreme Soviet is the Soviet legislature and in theory the highest organ of the Soviet Government. It consists of two equal houses—the Soviet of the Union and the Soviet of Nationalities. Elections to the Supreme Soviet are held every 4 years and a single list of candidates is nominated by the Communist Party. Between the infrequent sessions of the Supreme Soviet, its Presidium functions on its behalf. The Chairman of the Supreme Soviet Presidium (presently Leonid Brezhnev) also acts as titular Chief of State. The Supreme Soviet plays no significant role in the actual govenment of the country. Election to the body is sometimes a ceremonial honor bestowed on political figures, scientists, cosmonauts, artists, and others.

THE COUNCIL OF MINISTERS

The Council of Ministers is the most significant organization of the Soviet Government. Its approximately 100 members are nominally appointed by the Supreme Soviet and theoretically they are responsible to that body. In practice the Council of Ministers is selected by and responsible directly to the Central Committee of the Communist Party. The Chairman of the Council of Ministers, presently Nikolay A. Tikhonov, is also the Premier or Prime Minister of the Soviet Union.

Directly under the Council of Ministers are the ministries, state committees, and other bodies which carry on the day-to-day tasks of Soviet Government. The Soviet Academy of Sciences also falls under the supervision of the Council of Ministers. Below the ministries are the industrial branches and the institutions which fall within the jurisdiction of each.

Central Committee policy guidelines on space, on the basis of established patterns, would pass directly to the Council of Ministers. Theoretically, the Council of Ministers is responsible to the Supreme Soviet, but in terms of the structure of the real decisionmaking process, the Supreme Soviet appears to play no role. The passing of directives from the Central Committee of the Communist Party to the Council of Ministers is simplified by the fact that the Chairman of the Council of Ministers, the 10 Deputy Chairmen, and the heads of the subordinate ministries, state committees and other agencies all simultaneously hold high party offices. Six of the 13 full members of the Politburo are also members of the Council of Ministers. For a period, under Joseph Stalin and later Nikita Khrushchev, the General Secretary of the Communist Party also assumed the position of Chairman of the Council of Ministers (Premier). Those duties are now separated, with Soviet leader Brezhnev acting as General Secretary of the party and Nikolay Tikhonov acting as Chairman of the Council of Ministers. At the same time, Tikhonov is a ranking member of the Politburo, although not a member of the Party Secretariat.

The Soviet Constitution refers to the Council of Ministers as the highest executive and administrative organ of the state. It is the government's central coordinating, planning, and controlling body, and is accountable directly to the CPSU. While the Soviet Constitution gives the council no legislative authority, it does in fact issue orders and decisions that become law. Major government policy decisions are made in the Presidium of the Council of Ministers on the basis of party guidelines and directives.[15]

Members of the Presidium of the Council of Ministers, aside from Chairman Tikhonov and who may play a significant role in the space organization, are the Chairman of the State Committee on Science and Technology, Nikolay K. Baybakov (Chairman of the State Planning Committee), Veniamin E. Dymshits (Chairman of the State Committee for Material and Technical Supply), and Leonid V. Smirnov (Chairman of the Military Industrial Commission). Non-Presidium members who head ministries and other departments subordinate to the Council of Ministers with a probable input into the space program include Sergey A. Zverev (Minister of Defense Industry), and Konstantin N. Rudnev (Minister of Instrument Making, Automation Equipment and Control Systems).[16]

STATE COMMITTEE ON SCIENCE AND TECHNOLOGY

The State Committee on Science and Technology is the highest government coordinating body for scientific work, at least in the civilian sector. There are differences of opinion among Western analysts regarding the role the committee plays in the space organization. It is generally thought to have a significant role. Some analysts view it as the chief coordinating body of the space program. Still others see it as an intermediary between the central space institution and the government and party leadership.[17] On the other hand, its position may be limited to that of coordinating some of the associated research and development activity contributing to the space program.

The precursor of the committee was the State Committee for Coordination of Scientific Research, established in 1961 under Nikita Khrushchev for the purpose of adapting basic research to industrial development. It was created in conjunction with the reorganization of the Soviet Academy of Sciences. Narrow engineering institutes were moved from under the jurisdiction of the academy and placed under the corresponding industrial ministries. Henceforth, the State Committee for the Coordination of Scientific Research would replace the academy as coordinator of Soviet science, leaving the latter as an institution of basic research.[18] The action by the Khrushchev leadership was at least in part politically motivated.

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[15] Amerian University. Foreign Area Studies. Area Handbook for the Soviet Union. Washington, U.S. Government Printing Office, 1970, pp. 390–393.

[16] U.S. Central Intelligence Agency, Reference Aid: Directory of U.S.S.R. Ministry of Defense and Armed Forces Officals.

[17] Smolders, Peter L., Soviets in Space: The Story of the Salyut and the Soviet Approach to Present and Future Space Travel. Guilford, Lutterworth Press, 1973, p. 29.

[18] Amerian University, Foreign Area Studies. Area Handbook for the Soviet Union, pp. 354–355.

On the one hand it appeased those pure scientists in the academy who resented the growing intrusion of engineers in the membership and the redirecting of the academy's work toward the industrial sector. On the other hand, it reversed the trend under which the academy accumulated increasing authority as the central scientific organization of the Soviet Union. The diffusion of its responsibilities may have been undertaken to eliminate what the party viewed as a potential threat to its paramount position in the field of science.

The committee was renamed in 1965, reemerging as the State Committee for Science and Technlogy. Under its new name, the committee continues to be responsible for coordinating Soviet research and development (primarily in the civilian sector), establishing priorities, and introducing new technology into the industrial areas. Furthermore, the committee oversees the numerous research institutes and laboratories now under the industrial ministries.[19]

One feature of the committee, since its birth, has been the preponderance of officials from the defense industrial sector among its ranks. The first two chairmen, M. V. Krunichev and K. N. Rudnev both had defense related backgrounds. Indications are that the committee does not coordinate activities of the defense industries.[20] The only seeming explanation for the presence of the defense people in its ranks is that the defense establishment has significant influence over the civilian scientific and technological establishment.

THE STATE PLANNING COMMITTEE

The State Planning Committee (GOSPLAN), under the direction of Nikolay K. Baybakov, is responsible for planning scientific, technological, and economic activities in the Soviet Union, as well as exercising budget control. It falls in the Ministerial and State Committee structure directly under the Council of Ministers. It has an input into most Soviet undertakings, especially those such as the space program, in which numerous organizations and sectors of the economy are involved. Within the State Committee are a number of regional and functional departments. The committee is also responsible for overseeing plan fulfillment. One of its most important duties is to participate in formulating the overall short- and long-term plans of the Soviet Union, such as the Five Year Plan.[21]

Very little is known of the relationship between the space organization and the State Planning Committee. It is generally assumed that the space program falls under the system of precise advance planning, prevalent throughout the Soviet Union. Integration of the space program with the other national undertakings would seem to require a considerable degree of involvement by the committee.

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[19] American University, Foreign Area Studies. Area Handbok for the Soviet Union, pp. 390-393.

[20] Gallagher, Mathew P., and Karl F. Speilmann. Soviet Decision-making for Defense: A Critique of U.S. Perspectives on the Arms Race. New York, Praeger, 1972, p. 68.

[21] American University, Foreign Area Studies. Area Handbook for the Soviet Union, pp. 609-611.

DOMINANT ROLE OF THE MILITARY ESTABLISHMENT

Since the early history of Soviet space and rocket research there has been a close tie between the scientists and the military establishment. Scientists and inventors learned very early that under the Soviet system, the best way to get generous and quick funding for a project was to impress upon the military the defense or strategic value of the undertaking. The initial research institutions dealing with rocketry, such as the Leningrad Gas Dynamics Laboratory, were established under the control of the armed forces. The secrecy cloaking Soviet space research can at least in part be explained by the military link. Soviet space scientists themselves are said to have a history of "secrecy consciousness." On the whole, Soviet space scientists have not been "prolific recorders of their findings." [22]

Western opinion varies on the military-civilian mix of the Soviet space organization, today, and on the degree of separation between the military and civilian aspects of the program. The Soviets themselves claim that their entire space program is purely scientific and peaceful in purpose, which is known not to be the case.[23] In fact, there appears to be general consensus among Western experts that the military is deeply involved in the program. Some analysts see the military establishment as controlling essentially only the military side of the space program, with a large part remaining in civilian hands.[24] Other observers have expressed the opinion that the military shares with the Soviet Academy of Sciences, the organizational control of the program.[25] Foy D. Kohler has suggested that rather than a NASA-type central agency, existing organizations, "particularly within the military establishment," are primarily responsible for directing the program.[26] Dr. Thomas O. Paine, the former Administrator of NASA, in testimony before Congress in 1970, attributed a key role to the military in the space program. He said:

> The Soviet space program is generally considered to be directed by the Soviet military, and public analyses indicate that a very considerable proportion of flights no doubt serve military purposes.[27]

The military establishment exerts general influence on policy at the ministerial level through the Defense Ministry with input from the five military branches. Perhaps more significantly, the military has a direct input at the highest party level through the membership in the Politburo of Defense Minister Dimitriy Ustinov and the presence of numerous military officers in other high party offices. This factor in itself would allow the military to have an influence over the space organization at the very top. It is generally believed, however, that the military establishment exercises more direct influence over the program.

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[22] Daniloff, Nicholas. The Kremlin and the Cosmos. New York, Knopf, 1972, pp. 30–32.

[23] U.S. Congress. House Committee on Science and Astronautics. Review of the Soviet Space Program; With Comparative United States Data. Prepared by Charles S. Sheldon. Washington, U.S. Government Printing Office, 1967, p. 81.

[24] See, for example, U.S. Congress. Senate Committee on Aeronautical and Space Sciences. Soviet Space Programs, 1962–65, p. 147.

[25] Ulsamer, Edgar. The Soviet Space Effort: Still Increasing. Air Force Magazine, vol. 56, October 1973: 56.

[26] Kohler, Foy D., and Dodd L. Harvey. Administering and Managing the United States and Soviet Space Programs. Science, vol. 169, Sept. 11, 1970: 1050.

[27] U.S. Congress. House Committee on Science and Astronautics. 1971 NASA Authorization, vol. 1. Hearings held February 17, 19, 20, 24, 25, and 26, 1970. Washington, U.S. Government Printing Office., 1970, p. 13.

The Soviet Defense Ministry, which is directly under the Council of Ministers in the government structure, is charged with directing, administering, and supporting the military branches. The Defense Minister and his three First Deputy Ministers head the organization. At the next level are the other deputy ministers, incuding the commanders-in-chief of the major military branches and the most important support branches. Below this level are the General Staff and the Main Political Administration. The Main Political Administration, which acts as the party's "watch dog" in the military is simultaneously a section of the Party Central Committee, adding another significant link. The next level in the military hierarchy includes the operating commands.[28]

A striking difference between the Soviet defense structure and, for example, its American equivalent, is that the Soviet establishment consists of military men from top to bottom. Dimitriy F. Ustinov is the first civilian to occupy the position of defense minister.

In terms of the Soviet space program, an important characteristic of the Defense Ministry is its relationship with the strategic industries which manufacture the hardware. While structurally these industrial sectors are under the Defense Industries and other ministries, directly under the Council of Ministers, they are in practice controlled by the military establishment, according to some analysts.[29]

Below the Ministry of Defense, the five coequal branches of the military are the Army, Navy, Air Force, Air Defense Command, and the Strategic Rocket Force. The Air Force and the Strategic Rocket Force have a direct operational role in the space program.

THE STRATEGIC ROCKET FORCE

The Strategic Rocket Force conducts all space rocket launches whether for military or civilian purposes. It was established in 1960 and is the elite branch of the Soviet military. The primary mission of the force is to launch strategic nuclear missiles. The size of the force has been estimated at 250,000 men. Very little is known of its organizational structure. It is commanded by Gen. Vladimir F. Tolubko who replaced Kikolay I. Krylov upon his death in 1972. He is a member of the Central Committee of the Soviet Communist Party.[30]

The Strategic Rocket Force is thought to operate some tracking stations and tracking ships. It also may exercise some control over the launch facilities.

THE AIR FORCE

The Soviet Air Force is responsible for cosmonaut training at Star Village (Zvyezdni Gorodak) near Moscow and for the recovery of spacecraft. The chief of cosmonaut training is Maj. Gen. Vladimir A. Shatalov, himself a veteran cosmonaut.[31]

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[28] Gallagher and Spielmann, Soviet Decision-making for Defense, pp. 38-39.

[29] U.S. Congress. Committee on Aeronautical and Space Sciences. Soviet Space Programs, 1966-70. Washington, U.S. Government Printing Office, 1971, p. 85.

[30] U.S. Central Intelligence Agency. Reference Aid: Directory of U.S.S.R. Ministry of Defense and Armed Forces Officials. April 1980. p. 29. (CR-80-11888)

The Soviet Air Force, or long-range Air Force as it is sometimes called, is distinct from the Air Defense Command, which is responsible for the defense of the Soviet Union and other Warsaw Pact countries from foreign attack. The Air Force has been compared to the U.S. Strategic Air Command since its mission may be similarly limited. The advent of the missile age and the establishment of the Strategic Rocket Force to man the missiles has diminished the overall role of the Air Force.[32] The Air Force is presently commanded by Chief Marshal of Aviation Pavel S. Kutakhov, a full member of the Central Committee of the Communist Party.[33]

ROLE OF THE SCIENTIFIC ESTABLISHMENT

OVERVIEW

Soviet party leader Brezhnev in his speech marking the 250th anniversary of the Soviet Academy of Sciences said that the country had more than a million people working in various fields of science, calling it a "great force that must be used properly." [34] It is not definitely known what percentage of these people work on the Soviet space program, or how precisely they are organized. The Communist Party exercises varying degrees of control over the entire scientific establishment.

The National Science Foundation sponsored a study on Soviet research and development which concluded in part:

> The cardinal aspect of Soviet organization for research and development stems from the fundamental nature of the Soviet State wherein the allocation and employment of natural resources are determined and enforced by the central government. As is true for all economic, cultural, and other functions of Soviet society, the lines of control over research and development progressively converge toward the apex of State power, the Central Committee of the Communist Party and its executive branch, the USSR Council of Ministers. All basic decisions on the scale, direction, and organization of research and development are made or are subject to confirmation at that uppermost level of authority as if by the directors of a giant, nationwide, all-inclusive holding corporation.[35]

The dependent relationship of the scientists to the Communist Party is just as emphatically underscored by Soviet leaders. On this subject Leonid Brezhnev said:

> Socialism and science are indivisible, and this is the reason for the victory of socialism. Socialism alone makes possible the utilization of the gains of science in the interest of the people and makes it possible to bring to light the creative potential and talents that abound in every people. . . .
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> . . . I would like to pay special attention to a highly important problem—the Party spirit of our science. In whatever branch Soviet scientists work, they are always distinguished by one characteristic—a high level of Communist consciousness and Soviet patriotism.[36]

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[31] Smolders, Peter L. Soviets in Space: The Story of the Salyut and the Soviet Approach to Present and Future Space Travel. Guilford, Lutterworth Press, 1973, p. 30.

[32] American University, Area Handbook for the Soviet Union, p. 586.

[33] U.S. Central Intelligence Agency. Reference Aid: Directory of U.S.S.R. Ministry of Defense and Armed Forces Officials, p. 21.

[34] Academy of Sciences' 250th Birthday, p. 4.

[35] Korol, Alexander G. Soviet Research and Development: Its Organization, Personnel, and Funds. Cambridge, Mass., The M.I.T. Press, 1965, p. 3.

[36] Academy of Sciences' 250th Birthday, p. 2.

The scientists are said not always to welcome the party's control over their work. Some analysts view the party-science community relationship as one of chronic tension. This may be explained partially by the fact that Soviet science has been subjected to party control without the scientists themselves having been integrated, to any significant degree, into the government decisionmaking process. On the whole, analysts believe, American scientists have more influence on policy than their Soviet counterparts through institutions such as the President's Science Advisory Committee or the Special Assistant for Science and Technology. Ironically, such American institutions were established in response to the Soviet Sputnik challenge.[37]

This is not to imply, however, that individual space scientists have no input into top-level decisionmaking. On the contrary, their influence, at times, can be significant. It was reportedly Sergey Korolev, the former Chief Designer and major figure in the Soviet space program, who convinced Khrushchev to provide major support and funding for the Soviet space program by promising that, given the proper tools, he could beat the United States in sending up a Sputnik for the International Geophysical Year in 1957.[38] However, Soviet scientists do not appear to be involved in the decisionmaking on an institutional or sustained basis.

An important factor in viewing the Soviet space organization is the distinction that exists within the Soviet science establishment between what one analyst calls civilian scientists and defense scientists. There is a striking contrast between the scientific achievements to date of the defense sector on the one hand, and the civilian sector on the other. The defense sector has had remarkable successes, while the civilian sector has had very mixed results, including stagnation in many areas, over recent years. Defense research and development receives preferential funding which in turn has the effect of providing the defense scientists with more favorable working conditions than their civilian counterparts. It has been estimated that the defense sector, in the broad sense, receives as much as 80 percent of research and development allocations.[39] In this estimate, the entire space effort is included in the defense category, on the grounds that the space program has had the success, commitment of resources, and preferential treatment characteristic of that category.

Many analysts believe that funding alone does not explain the greater effectiveness of defense and space research and development. They see a more efficient organization in the strategic areas. The views of these experts were reinforced in a 1962 speech by Premier Khrushchev. He attributed Soviet success in these areas to the "centralization and concentration of scientific and design forces in the appropriate committees" and admitted that this sort of efficiency did not yet exist in other areas.[40] Leonid Brezhnev could make the same statement 20 years later.

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[37] Juviler, Peter H., and Henry W. Morton, eds. Soviet Policy-making: Studies of Communism in Transition. New York, Praeger, 1967, p. 58.

[38] Gallagher and Spielmann, Soviet Decision-making for Defense, pp. 72-73.

[39] Ibid., pp. 55 and 66.

[40] Pravda, Nov. 20, 1962; cited in Gallagher, (op. cit., p. 68.)

Despite the differences between the two scientific sectors (defense and civilian), they share many common problems. One factor that probably works against rapid progress in space research is the existing compartmentalization of scientific work. One scientist or group of scientists does not necessarily know what the other is doing. Scientists throughout the Soviet system are said to be plagued by an inability to gain from the free flow of ideas and information upon which Western scientists, for example, rely heavily.

THE SOVIET ACADEMY OF SCIENCE

GENERAL ORGANIZATION

The Academy of Sciences is the most visible institution of the Soviet space organization. The Soviet Union presents it as the counterpart of the U.S. National Aeronautical and Space Administration in its space role. In negotiations with NASA on space cooperation, the Soviet Union has been represented by academy officials. Some leading Western experts subscribe to this dominant position attributed to the organization by Soviet spokesmen. The Dutch expert Peter Smolders maintains that under the control of the top party and government organizations, the actual "coordination of all space activities, manned as well as unmanned flights, is in the hands of the Soviet Academy of Sciences." [41]

Other observers agree that the academy is one of the institutions heavily involved in the space organization, providing research support, consultation, and acting as spokesman for the program at home and abroad, but dispute the central role within the organization attributed to it. They do not deny that key figures in the academy might actually be involved in the central coordination of the space effort in other capacities. For example, the former academy president, Mstislav V. Keldysh, is recognized as a prominent space scientist. The Soviet press has associated the "successes of the USSR in the exploration of space" with his name and has referred to him as "an organizer and initiator" of the space program.[42] Furthermore, membership in the academy is a form of recognition for which leading space scientists seem to be prime candidates.

The evidence generally used to support the arguments of those who doubt the central role of the academy as an institution in the space organization is that (1) its scope of responsibility has become too limited as a result of the various reorganizations for the academy to play the role of coordinator; and (2) the Soviet Communist Party leadership and the military establishment seem to have a historical mistrust toward the academy (despite the esteem in which they hold it) that would make it unlikely for them to give the institution the central coordinating role.

Membership in the Soviet Academy of Sciences is one of the highest honors conferred by the Soviet state. The functions of the academy encompass not only the natural sciences, but also the social sciences, law and humanities. The academy is considered to be the leading center of basic and applied research in the Soviet

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[41] Smolders, Soviets in Space, p. 29.
[42] The New York Times, May 31, 1971: 32.

Union. Under the academy are 14 Republic academies and 7 branches. It serves as coordinator for the pure scientific research carried on by the academies of the Union republics and the specialized institutes.[43] In all, the academy incorporates 250 scientific institutions and employs over 160,000 people, 40,000 of whom are highly trained researchers.[44]

The highest body of the academy in the formal structure is the General Assembly, which includes all the regular and honorary members. Real control is exercised by the Presidium of the academy. The Presidium members for the most part hold high-level party posts. They act as the channel for party and government directives. Below the Presidium is the Scientific Secretary. Under him are the councils, departments, and agencies. As elsewhere in the Soviet system, the party exercises control from the top and at every level of the academy. Political secretaries are assigned to every institute and department. The acting president of the academy is V. A. Kotelnikov.

The academy was reorganized in 1963, when reforms mentioned by Khrushchev as early as 1956 were instituted. On the basis of the reforms, the academy remained the central coordinator of theoretical research. Many organizations, such as the Institute for Metallurgy were transferred to the industrial ministries. The academy continued to carry on some engineering research of fundamental importance, but it no longer worked on the practical applications.[45] As a result of the reorganization, the academy remains the single most important and prestigious scientific institution in the Soviet Union. However, it has lost its position in the overall administration of Soviet science and technology.

Within the structure of the academy are to be found several commissions and sections directly involved in the space program. Other space commissions may fall under the jurisdiction of the academy. Some of these units probably contribute significantly to the space effort, while others may serve primarily as a front for the more secret space effort.

SPACE INSTITUTIONS UNDER THE ACADEMY

Under the auspices of the Soviet Academy of Sciences are numerous commissions, institutes, and organizations which deal with various aspects of space research. In 1954, an organization was established under the title Interdepartmental Commission for the Coordination and Control of Scientific-Theoretical Work in the Field of Organization and Accomplishment of Interplanetary Communications. It was headed by Leonid I. Sedov and included, among others, Pyotr L. Kapitsa and Anatoly A. Blagonravov. The main function of the Interdepartmental Commission was to coordinate scientific research aimed at launching a Soviet Sputnik. It was also reportedly responsible for developing experiments to be carried out in space, for publicizing Soviet space achievements, maintaining contacts with foreign space organizations, and sending scientists to represent the Soviet Union at international space conferences.[46]

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[43] Juviler and Morton, Soviet Policy-making, p. 134.
[44] Academy of Sciences' 250th Birthday, p. 4.
[45] Juviler and Morton, Soviet Policy-making, p. 155.
[46] Daniloff, The Kremlin and the Cosmos, pp. 56, 76–77.

The Interdepartmental Commission was reportedly superceded by the Commission on the Exploration and Utilization of Space, headed by Blagonravov.[47] (Soviet sources refer to it as the Commission for the Study and Use of Outer Space.)[48]

Another institution apparently under the auspices of the Academy of Sciences is the Commission for the Promotion of Interplanetary Flights, headed by Leonid I. Sedov (formerly with the Interdepartmental Commission and Vice President of the International Astronautical Federation).[49] The organization is also referred to as the Commission for Space Travel.[50] At least one of its important duties seems to be as spokesman and representative internationally for the Soviet space program.

A major agency of the Academy of Sciences is the Council for International Cooperation in the Studies and Uses of Outer Space (Interkosmos). The council is the coordinator for all cooperative space ventures with the countries of Eastern Europe, to which the Soviet Union attributes major political significance. Chairman of the council is Boris N. Petrov, considered a foremost expert in cybernetics and the theory of automatic control. He is also the Director of the Department of Mechanics and Control Processes at the academy and a profession at the Moscow Aviation Institute. Furthermore, he is another leading international spokesman for the Soviet space program.[51]

The Institute of Space Research, directed by R. Z. Sagdeyev is one of several advanced research centers operated by the academy.[52] Some of these institutes offer advanced university degrees.

The Soviet Academy of Sciences also operates some of the space tracking stations within the Soviet Union and 10 of the tracking ships operating around the globe. Other space communications ships are operated by the Navy and the Strategic Rocket Force. The Coordination and Computing Center which analyzes communications received from space is also reportedly under academy administration, as is Star Village (Zvyezdni Gorodok), at least formally, where the cosmonauts are trained by the Air Force.[53]

INPUT FROM THE UNIVERSITIES

Universities in the Soviet Union are thought to have less of an input into research and development than their American counterparts. The institutes of higher learning conduct much of their own research. But their work does not seem to be integrated with the research performed at the academy and elsewhere. This departmentalization inhibits the exchange of technological information between the universities and the space organization and among the universities themselves. Furthermore, it is said to work to the detriment of the ability to improvise in the space program.[54] The universities may constitute a large untapped or wasted resource in the Soviet space program.

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[47] Beck, (op. cit), p. 148.

[48] Lebedev, Lev. Soviet Space Research. Space World, vol. k-11-131, November 1974: 22.

[49] Gwertzman, Bernard. High Space Costs Backed in Soviet. New York Times, Feb. 28, 1971: 20.

[50] Smoiders, Soviets in Space, p. 29.

[51] Pond, Elizabeth. Soviets Plan to Land on Venus. Christian Science Monitor, June 17, 1975: 1, 9.

[52] The Soyuz 13 Flight. New York Times, December 19. 3: 12-13.

[53] Smolders, Soviet in Space, p. 30.

[54] Coexistence in Space? Swiss Review of World Affairs, vol. 25, August 1975: 3.

THE QUESTION OF A CENTRALIZED SOVIET SPACE AGENCY

THE EVIDENCE

Over the years Western experts have been interested in the question of whether there exists a central coordinating agency for the Soviet space program. There is evidence and strong opinion on both sides, but no proof. Clearly, an undertaking of the scope of the space program needs high-level coordinating. While it is an accepted fact that at the highest level oversight comes from the Communist Party leadership, it also stands to reason that this group does not conduct the day-to-day management of the program.

The specific questions involved in the space agency speculation are: (1) Whether a central agency, distinct from the institutions already discussed, exists at all; (2) if a separate coordinating mechanism exists, whether it is a formal agency rather than an informal grouping along "Manhatten Project" lines; and (3) the structure and membership of such an organization.

In 1963, the Aerospace and Technology Division of the Library of Congress released a study on the management of the Soviet space program, together with organizational charts, according to which the Soviet space program was headed by the State Commission for Space Exploration, directly under the Council of Ministers.[55] The Soviet press on very rare occasions has referred to a "State Commission." In general, however, the Soviet media speaks obliquely about the "collectives" of scientists and other talent. In 1972, an American reporter visiting "Star Village" near Moscow spoke of the "State Commission" clearing the spacecraft for launch, and said that while the identity and scope of the organization is not known, it is presumed to incorporate many of the functions of NASA.[56]

Another observer, Nicholas Daniloff, quotes one source as having identified the Soviet space agency as the "State Commission for the Organization and Execution of Space Flight." [57] He also attributes responsibility for all launches to the commission.

Other analysts believe that the Soviet Union has no space agency which approximates America's NASA.[58] In place of such an organization, they perceive an elaborate system of coordination among participating institutions on an informal basis. One observer sees a "tendency to resort to ad hoc arrangements to override whatever barriers exist" in high priority fields of Soviet research and development. This he believes functions only because of the intimate participation by the Soviet leadership. Top officials can intercede quickly when stumbling blocks and jurisdictional bottlenecks, such as plague much of the civilian sector, develop.[59]

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[55] U.S. Library of Congress. Aerospace Technology Division. Management of the Soviet Space Program. Washington, October 1963 (ITS: AJD Report, pp. 63–117).

[56] Wilford, John Noble. Soviet Space Center: Hope Amid Expansion. The New York Times, Mar. 22, 1972: 1, 20.

[57] Daniloff, The Kremlin and the Cosmos, p. 56.

[58] See, for example, Ulsamer, The Soviet Space Effort, p. 56.

[59] Gallagher and Spielmann, Soviet Decision-making for Defense, pp. 72–73.

THE STRUCTURE

The central coordinating mechanism of the Soviet space program probably includes representatives from the upper echelons of the Communist Party, the military establishment, the scientific establishment, and the industrial ministries and state committees that have an input into the space program. The top positions in the organization have been identified as including a chairman, one or more deputy chairmen, a launch director, the chief designer, and the chief theoretician of cosmonautics.[60] Other probably high-level members come from the military, including Air Force and Strategic Rocket Force representatives, and from the scientific and industrial sectors.[61]

SPECULATION ON INDIVIDUAL IDENTITIES

The chief officials and scientists of the Soviet space program must bear the burden of working in complete anonymity. Nikita Khrushchev frequently explained that the secrecy surrounding their identities was necessary to protect them from the threat of assassination. As a result, guessing the identities of space officials has become a lively game in the West. The Soviets only disclose the identities upon the deaths of space leaders. However, occasional clues do appear in the Soviet media inadvertently.

There were reportedly occasions in the past when imposters were actually paraded to conceal the real identities of space figures. According to one account, Sergey P. Korolev, who was the chief designer and leading scientist in the Soviet space program, became infuriated because L. I. Sedov was being presented at international congresses as the leading Soviet space scientist. When the Western press began to refer to Sedov as the father of the Sputnik, Korolev allegedly demanded of Khrushchev that the true identities of all the people involved in the launching of the first Sputnik be published. While Khrushchev did not comply with this demand, all further reference to Sedov as the man behind Sputnik were reportedly stopped.[62]

The position of chairman in any national coordinating commission on space would, at least formally, be the most important. Dimitriy F. Ustinov, previously referred to as the top Soviet official on space in his Politburo capacity, has been suggested as a possible chairman of a "State Commission." Whether Ustinov, as a Politburo member would become involved in the day-to-day administration of the space program is open to question. Some of the speculation on the position is based on the perceived identity of the earlier chairman who was thought by many to be Konstantin N. Rudnev, now the head of the Ministry of Instrument Making, Automation Equipment and Control Systems (and probably still influential in the space program). He had been in charge of defense industries from 1958–61 prior to becoming chairman of the precursor to the State Committee on Science and Technology while allegedly heading the "State Commission." He was also a Deputy Chairman of the Council of Ministers. A man who possessed a very similar background, and was, therefore, a logical subject of speculation regarding the chairmanship, was Vladimir A. Kirillin prior to his demotion in 1972.[63]

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[60] All mention of the chief theoretician has been dropped and the position probably no longer exists.

[61] U.S. Library of Congress, Management of the Soviet Space Program, fig. 3; and Daniloff, The Kremlin and the Cosmos, p. 78.

[62] Vladimirov, Leonid. The Russian Space Bluff. London, Tom Stacey Ltd., 1971, p. 19.

Leonid V. Smirnov and Sergey A. Zverev are two other people who, on the basis of their present positions and backgrounds in areas associated with the space and defense fields, could be considered possible candidates for the position of Chief Space Coordinator. Smirnov is Chairman of the Military-Industrial Commission and a Deputy Chairman of the Council of Ministers. Zverev holds the important post of Minister of Defense Industries.

Korolev held the position of Chief Designer of the Soviet space program until his death in 1966. In this capacity he presumably worked under the direction of the chairman. However, on frequent occasions he is said to have reported directly to Premier Khrushchev. He was responsible for the scientific and technological aspects of the Soviet space program. According to some sources, Korolev also held the positions of Launch Director and Deputy Chairman of the "State Commission." [64] It is unlikely that one man replaced him in all three positions.

Mikhail K. Yangel is believed by some observers to have replaced Korolev in the position of Chief Designer. When Yangel died in 1971, a Tass Soviet news agency obituary called him the "outstanding scientist and designer in space technology" and the "man who raised a galaxy of outstanding designers and scientists." It said that he had made a unique contribution to the unmanned lunar program and the Venus and Mars programs. He was also said to have had a major role in the area of manned space flights. Yangel was a full member of the Soviet Academy of Sciences and of the Supreme Soviet. He had received the highest Soviet honors during his life. After World War II he is known to have worked on Soviet aviation and rocketry and is said to have directed a top national rocket design bureau.[65]

Since Yangel's death, speculation on the identity of the Chief Designer has involved Vladimir N. Chelomei. He is known to be a prominent figure in the Soviet space program. He is thought by some observers to have had a position rivaling that of Korolev under Khrushchev. Chelomei graduated from the Kiev Aviation Institute and designed jet aircraft engines during World war II. After the war he began to work in the rocket field. He became a Bauman Engineering School professor in 1952. He, too, is a Supreme Soviet Deputy.[66]

Other names have been mentioned from time to time as possible members of the "State Commission." Valentin P. Glushko is know to have been a designer of rocket engines. In early Soviet space literature his name was linked with that of Korolev and Tikhonravov. He has been suggested as the possible Chief Designer of Rocket Engines.[67]

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[63] Daniloff, The Kremlin and the Cosmos, p. 81.

[64] Ibid., p. 78.

[65] Mikhail Yangel Dies; Soviet Space Scientist. The Washington Star, Oct. 27, 1971: B5.

[66] Shabad, Theodore. Russians Indicate Rocket Specialist Heads Space Program. The New York Times, July 14, 1974.

[67] Daniloff, The Kremlin and the Cosmos, pp. 84–85.

In his obituary, Alexei Isayev was identified by Tass as the chief designer of the rocket engines for the Vostok, Voskhod, Soyuz, and Mars spacecraft. Very little was revealed about his background other than that he was a university graduate who worked in the field of aviation and rocket engine development. He was called one of the main creators of the first Soviet jet in 1942. In his lifetime he had received the highest government honors and awards.[68]

Leonid I. Sedov, as a specialist in mechanics an aerodynamics is also thought to have an important role in the program, even though he may not be "the father of Sputnik" as the Western press at one time suggested.

A final point which has interested Western observers concerns the true identities of leading space scientists who write articles in the Soviet Union under pseudonyms. Key figures in the space program are known to have used this approach to maintain their anonymity in the past. Korolev allegedly used more than one pseudonym in his lifetime. A former Soviet journalist who at one time wrote about the space program said that Korolev regularly wrote articles for Pravda under the pseudonym "Konstantinov." [69] He is also thought to have been the author of articles under the name Professor K. Sergeyev. These articles were generally New Year's reports on the Soviet space program. If he indeed wrote the articles, he merely reversed his two names. This has led to speculation that the articles which started to appear in the late 1950's by Professor G. V. Petrovich may have been written by Valentin P. Glushko, the rocket engine designer.[70] Without speculating on pseudonyms used by other leading space scientists, it can be guessed that some of the signatures appearing on articles today may be pseudonyms for key space figures.

PROSPECTS FOR THE SOVIET SPACE PROGRAM IN A PERIOD OF LEADERSHIP TRANSITION

While there are more questions than answers concerning the management of the Soviet space program, it is clear that the program could not have been as successful as it has been without a strong leadership commitment at the top. Now the Soviet Union faces a leadership succession at a time when competition for scarce resources among different Soviet sectors is intensifying. It remains to be seen whether the same level of commitment to the space program will be maintained by a new group of leaders.

The Soviet leadership is now one of the oldest among the world's ruling establishments. Party leader Leonid Brezhnev appears to remain in firm control, but he is 75 years old. The full members of the Communist Party Politburo average 70 years of age, some suffering from declining health. The age distribution is not much different in other centers of power within the Soviet party and government. Thus the men who have guided the Soviet Union since the mid-1960s are likely to be replaced in the not-too-distant future. With very few exceptions, no effort has been made to bring younger people into the top levels of the leadership hierarchy. The transition to a new leadership may occur in two stages. In the first, a caretaker regime made up of the remaining leaders of Leonid Brezhnev's own generation would assume power. But before too long, a wholesale succession to a new generation is expected.

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[68] Soviet Rocket Designer Identified. The Washington Star, June 27, 1971: All.
[69] Soviet Rocket Designer Identified. The Washington Star, June 27, 1971: All.
[70] Daniloff, The Kremlin and the Cosmos, p. 84.

The Soviet leadership succession remains shrouded in mystery. There is no formal succession mechanism in the Soviet Union and the circumstances of each previous change in Soviet leadership has been unique. There has been considerable speculation in the West concerning the question of who will be Brezhnev's immediate replacement as leader of the Soviet Communist Party. Andrei Kirilenko, the 75-year-old Politburo member and Party Secretary, has been seen by many as the most likely interim successor. But there have been indications recently that his power is on the wane. At the same time, no one has clearly replaced him as the most likely candidate. The fastest rising members of the Soviet leadership include K. U. Chernenko, N. A. Tikhonov, and the youngest Politburo member, M. S. Gorbachov. The 70-year-old Chernenko and 50-year-old Gorbachov are members of both the Politburo and Secretariat. The 76-year-old Tikhonov, in addition to being a member of the Politburo, has replaced the late Alexei Kosygin as Soviet Premier. Others, such as KGB head Yu. V. Andropov and Moscow Party leader V. V. Grishin, remain very powerful. They are likely to occupy a key role, if not as candidates, then as selectors of the next leader. Of the possible candidates, Gorbachov has aroused greatest interest among Western experts because of his relative youth and rapid rise.

Discussion of the direction of Soviet policies following the succession is even more speculative than that concerning the identity of the successor. Many Western analysts expect a continuation of "Brezhnevism" without Brezhnev. They argue that because most of the top Soviet leaders are so closely identified with Brezhnev and his policies, and since the trend toward collective leadership has become established, no significant changes should be expected. This would suggest a continuing high level commitment on the space program. Yet policy differences within the Politburo on a number of occasions suggest that there is no unanimity of views even within this group. Also, the past record suggests that positions taken by Soviet officials on their way to power do not necessarily coincide with the policies they pursue once they assume the leadership.

The immediate Soviet leadership succession is likely to prove but a temporary measure. The refusal of the Brezhnev leadership to gradually bring younger people into positions of top-level responsibility is difficult to explain. A variety of possible reasons have been suggested by Western observers. First, there seems to be a strong commitment by Brezhnev and his colleagues to elite job security. This commitment has probably been a major source of Brezhnev's power. Second, there may be an inadequate pool of suitable candidates for leading positions from the next generation not only as a result of the heavy casualties suffered by that generation in World War II but also because of the disrupted educational and career patterns of the survivors. Many promising officials are two generations removed, currently occupying middle echelon positions in the central and regional party hierarchy. They have not yet reached positions of key responsibility and are, therefore, not well known in the West.

No one knows what type of policy changes might be implied by the emergence of a new generation of Soviet leaders. If there were to be a major shift in priorities away from military spending this could clearly have an effect on the size and pace of the Soviet space program. A few probable characteristics of the new generation can be assumed. On the one hand, they are likely to have been carefully selected and groomed by their predecessors to uphold the existing system. They are loyal to and have a self-interest in maintaining the party elite, in addition to other qualifications they may bring. On the other hand, they are better educated and better informed about the world than their predecessors. Their experiences also differ considerably. They have grown up in an era of unprecedented Soviet power, stability and prosperity, less affected by memories of revolution, war and purges that have shaped the Brezhnev generation. Yet they will inherit serious economic problems in the areas of agriculture, labor productivity, energy, and a lagging consumer sector.

Western analysts expected the 26th Party Congress, held in February and March 1981, to shed some light on the direction of the succession struggle, which many believe is already underway. A few high-level government personnel changes had been announced prior to the Congress, including the replacement of men whose careers were tied to the late Premier Alexei Kosygin. But no significant move toward solving the succession problem resulted from the Congress. Not a single member of the party's ruling Politburo or Secretariat was replaced, in contrast to most recent Party Congresses. Nor did the death of Mikhail Suslov in January 1982 bring any immediate change.

There were some modest changes in the make-up of the Party Central Committee. The membership was expanded. Some members who retired or died were replaced, others were added. But the changes did not go beyond normal past turnovers in Central Committee membership. Nor were there any numerically significant changes in the ethnic, social, or institutional composition of the Central Committee.

On the surface, the Congress indicated no shift in the balance of power within the Politburo, no challenge to the position of Leonid Brezhnev and his closest associates or to their policies. This type of continuity normally would be viewed as a sign of strength, stability and confidence in the leadership. Given the inevitability of the succession ahead, some analysts draw the opposite conclusion in the present case. They suggest that the balance of power within the leadership may be too precarious to allow any tampering with it. In any case, the postponement of action heightens the possibility of a more serious succession crisis when President Brezhnev and other top level Soviet officials do pass from the scene. This could have an impact on the future of the space program.

Chapter 5

Resource Burden of the Soviet Space Program*

INTRODUCTION

POST-STALIN SPACE DRIVE AND IMPERATIVE

Since its emergence to prominence in the 1950's, the Soviet space program has reflected national economic, political, and military goals to a larger extent than the U.S. program. The correlation of Soviet national objectives in military and civilian space has been facilitated by the apparent centralization of decisionmaking in the Politburo of the Communist Party.[1] Moreover, the administration of Soviet military and civilian space has been less distinctly separated than in the United States. Consequently, reliance on favored research and development institutions and the more sophisticated military-industrial support industries have placed Soviet space in the favored position with military claimants on resources. In a sense, the old resource allocation choice between "guns and butter" placed space in the preferred position of the former. Under Stalin's rule, it was clear that this broad question of resource allocation choice was not an operative policy issue. Only in the Brezhnev period, especially since 1967, does such a choice appear to have been an active consideration for party economic decisionmakers. In the modern Soviet context, for example, we may say that the decision to build new chemical fertilizer plants or new military or space facilities might result from these broad "guns or butter" type considerations by the top leadership.[2]

For most of the Stalinist period and the transitional rule of Nikita Khrushchev, resource allocations to the military and space programs were largely given or stipulated for Soviet economic planners. The special personal relationship of Academician Sergey Korolev and party leader Khrushchev doubtless contributed to the special space priority in the post-Sputnik period. With the passing of the two from the scene politically and physically, the space priority has probably been more institutionalized, and less personalized.

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*Prepared by John P. Hardt and George D. Holliday. Dr. Hardt is Senior Specialist in Soviet Economics and Dr. Holliday is Specialist in International Trade and Finance, Economics Division, CRS.

This chapter is based on a similar chapter appearing on Soviet Space Programs 1971-75, vol. II, pp. 85-98. Some modest updating to provide insights in the alternatives of the 1980's has been added.

[1] Cf. Francis T. Miko, Organization and Administration of the Soviet Space Program in this volume.

[2] Central Intelligence Agency, Soviet Economy: 1974 Results and Prospects for 1975, March 1975, p. 21.

EMERGENCE OF SPACE BURDEN IN POST-KHRUSHCHEV PERIOD

As the military claims on investment funds began to be assessed more critically in the late 1960's, the space claims may have come under increasing scrutiny. There appears to be an increasing awareness of the alternative use of scarce resources in the space program. The sophisticated demands of civilian investment programs for projects such as petrochemical plants appear to have been given increasing attention. In considering these competing demands for resources, the part of the space budget that did not contribute directly to military strategic systems was probably under the most severe pressure.

In assessing the resource burden, we have in mind two rather different kinds of questions:

1. Objectively, what were the quantity and quality of resources made available to the space programs?
2. Subjectively, how did the leadership appear to view the burden of space programs in terms of the options foregone in other allocations—the opportunity costs?

From the former measurement of resources devoted to space, we might also be able to throw some light on the question of the selective efficiency of the programs. Equivalent allocations to space programs in countries such as the Soviet Union and the United States probably resulted in different outcomes.

The more subjective questions of opportunity costs—although more difficult to assess—might provide insights on future program developments, help to explain past space program choices, or indicate a basis for the cooperative program in space. The alternative costs or perception of needs may have influenced Soviet decisions on competing with the United States in the "race to the Moon," choosing between manned and unmanned flights, and assigning priority to development of a space shuttle. Moreover, if the economic gains were deemed sufficient, the political costs of U.S.-Soviet space cooperation may have appeared more tolerable. To be sure, many of these choices were technologically constrained. However, the margin between economic and technological feasibility is difficult to establish with any precision. More funds for research and development might overcome technological constraints.

The objective question is primarily a measurement problem. Attempts to measure, in turn, are limited by the accuracy of Soviet data or the willingness to disclose the data and by problems of translating Soviet measurements—either in physical or monetary terms—into measurements susceptible to international comparisons. If Soviet leaders have been increasingly interested in choice among space and other programs, the accuracy of measurements may be presumed to have improved. However, the limitation on disclosure of information in the Soviet system makes such a judgment difficult to document. The secrecy system has been and continues to be so pervasive and restrictive that direct access to the kind of information normally available in the West is severely limited. Moreover, the access of many Soviet officials and professional analysts to Soviet data is also sharply restricted. This important information precondition is so crucial in influencing what an outsider may deduce or what most insiders may know, that a detailed discussion of the Soviet state secrecy laws, their current application, and impact is the first step in our analysis.

SOVIET SECRECY

ESTABLISHMENT OF THE STALINIST SYSTEM

For students of the Soviet economy, the barriers posed by official secrecy are formidable. Even in areas that have only marginal national security implications, such as crop forecasts, statistics on grain reserves, production of certain valuable minerals, and balance of payments accounts, economic data are closely guarded, and access is apparently limited to a very small number of officials and specialists. The Western observer who wishes to learn about such matters from Soviet publications is required to piece together various bits of related data, make some assumptions about how the Soviet economic system functions, and derive estimates that are often very crude. In military-related activities such as space spending, this task is even more complicated as the absence of published data is virtually absolute. For example, despite evidence of the existence of a large Soviet space program, no space expenditures are listed in the officially published Soviet budget. Soviet space officials add little to our knowledge of this subject, generally limiting themselves to generalizations about large or increasing space expenditures.

This extreme secrecy is in accordance with the policy followed by Soviet leaders since the late 1920's. The first signs of this policy came when the Soviet Government discontinued the previously rather liberal publication of various statistics related to the economic well-being of Soviet citizens.[3] The concept of "state secret" developed and was codified into law with the apparent goal of not only safeguarding national security but also protecting the regime from disclosure of politically embarrassing information that would reveal its priority system in resource allocations. The scope of information declared to be state secrets grew rapidly in conjunction with the leadership's attempt to develop Soviet military power and to impose economic austerity on the population while pursuing a policy of rapid industrialization.

On April 27, 1926, the Council of People's Commissars of the U.S.S.R. issued for the first time a "List of Information Constituting State Secrets." The list outlined three categories of state secrets: Military, economic, and "other" (primarily matters relating to foreign policy), in practice it provided the legal basis for party and government officials to withhold from public disclosure whatever they deemed necessary.[4] It was eventually superseded by revised lists promulgated on June 8, 1947, and April 28, 1956. The 1947 list was much more detailed and exhaustive than its predecessor. Not only were the types of secret military information more carefully detailed, but several kinds of nonmilitary information were added. Particularly noteworthy was the addition of a new category of classified information: "discoveries, inventions and technical improvements, and research and experimental work in all fields of science, technology and national economy, until they are finally completed and authorized to be published." [5] The new provision reflected a greater awareness by the leadership of the importance of scientific and technical progress to Soviet economic growth and military power.

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[3] Leon Herman, Varieties of Economic Secrecy in the Soviet Union, Santa Monica, Calif. The Rand Corp., December 1963, P—2849, p. 5.

[4] Sotsialisticheskaia zakonnost' (Socialist Law), 1926, No. 32, Item 213, cited in George Ginsburgs and Armins Rusis, Soviet Criminal Law and the Protection of State Secrets, in Z. Szirmai, ed., Law in Eastern Europe, Layden, A.W. Sythoff, 1963, p. 11.

POST-STALIN RETENTION OF SECRECY

The 1956 list provided the present legal basis for administering Soviet secrecy laws. Two later Soviet textbooks, published in 1970 and 1971, cited the list as being the law in force at that time.[6] While it is somewhat more moderate than the 1947 list, it still includes an imposing array of military and nonmilitary information as state secrets. Virtually any information related to military tactics and strategy, location and number of troops and bases, amounts of armaments and military equipment, and various other military matters are listed. Naturally, since Soviet space activities are carried out in facilities that have military as well as civilian applications, information about them is generally guarded as state secrets.

In addition, a wide range of information of an economic nature is included on the secrecy list. Examples of economic items on the list are indicative of the difficulties in analyzing sensitive economic activities such as space spending: [7]

> General information on the location of military-industrial enterprises, production capacities, plans for production of armaments, military equipment and ammunition and data on the fulfillment of the plans in concrete terms as a whole for the U.S.S.R. all-union and union-republic ministries, chief administrations, and enterprises of all-union significance; discoveries and inventions of major scientific and national economic significance before the heads of ministries and departments have granted permission for their publication; such other information as may be added by the Council of Ministers of the U.S.S.R. to the list of matters subject to state secrecy.

An important feature of this list is its open-ended nature. In practice, the last item in the list has been used as the basis for keeping secret whatever the leadership believes necessary. The application of this provision may also be retroactive. All of which enforces an environment of secrecy.

The penalties for disclosure of state secrets are specified in laws enacted in 1958 as part of a general legal reform in the early post-Stalin period. Four articles in the Statute on State Crimes, Articles 1, 2, 12, and 13 and one article in the Law on Military Crimes, Article 23, provide for a variety of penalties depending on the severity of the crime. Penalties range from death for treason and espionage to confinement for 2 to 5 years for smaller offenses, such as, "disclosure of state secrets."[8]

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[5] Ginsburgs and Rusis, op. cit., p. 28.

[6] Kurs sovetskogo ugolovnogo prava v shesti tomakh. Chast' osobennaia. Tom IV. Gosudarstvennye prestupleniia i prestu pleniia protiv sotsialisticheskoi sobstvennosti (Treatise on Soviet Criminal Law. Special Part, vol. IV. State Crimes and Crimes Against Socialist Property. Moscow, 1970:213; Sovetskoe Ugolovnoe Pravo. Osobennaia Chast' (Soviet Criminal Law. Special Part.), Moscow, 1971: 32–33.

[7] A. Valerian and Semen S. Studenkin. Sovetskoe Administrativnoe Pravo (Soviet Administrative Law), Moscow, Gosiurizdat, 1959, cited in Zigurd L. Zile, Robert Sharlet and Jean C. Love, The Soviet Legal System and Arms Inspection, New York, Praeger, 1972, pp. 223–224. The 1956 list of state secrets was renewed by decree of Sept. 15, 1966, F. J. M. Feldbrugge (editor) Encyclopedia of Soviet Law, Leiden: Oceans Publishers, 1973, p. 600.

The effect of such penalties is to inhibit any Soviet official from speaking or writing of matters that are routinely publicized in the West, unless prior approval has been obtained from top party leaders. One of the valuable aspects of U.S.-U.S.S.R. space cooperation has been the leadership's approval of release of certain kinds of information related to the Soviet space program. Such information, however, has not included data on Soviet space spending.

Soviet space allocations and space activities fit largely under the coverage of the pervasive secrecy system. As a result, direct information on either space budgets or activities are difficult to obtain directly from Soviet sources. To be sure, an annual state budget is published with single line items for military and science. Space activities are included in those categories. But there is no reason for confidence in any consistent interpretation on the comprehension, reliability, or comparative meaning of these figures. Likewise, the Soviet published information on space activities from which allocations might be derived are sketchy at best. Indeed, it seems fair to state the spirit of the Soviet state secrecy laws is an accurate gauge of intent, that is, allocations to space and accomplishments in space are by and large to be kept strictly secret. For Soviet officials who might wish to obtain access to such information and release it in their published works the criminal penalities of the legal system would seem to be an effective deterrent. Information on space therefore comes largely from four sources:

(1) Activities monitored in the West, especially by the United States.

(2) American intelligence estimates built largely on a complex aggregation of relevant data.

(3) Selective data released by the Soviet authorities largely for prestige purposes.

(4) Information obtained from scientific exchanges such as the Apollo-Soyuz Test Project.

The last two sources are very selective and incomplete measures of the Soviet space programs as a whole, especially over time. As a result, we must rely heavily on the estimates of Soviet space spending of the intelligence agencies in the United States, especially the Central Intelligence Agency and the Department of Defense. Even though published information by Soviet authorities is limited, the accuracy of Western estimates may be improving due to the effective use of technical means such as satellite surveillance.[9] Supplemented by comprehensive economic data, the process of setting parameters and estimating the scope and structure of Soviet space programs may be reasonably reliable.

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[8] Osnovy ugolovnogo zakonodatel'stva Soiuza SSR i Soiuznykh Respublik, Zakon ob ugolovnoi otvetsvennosti za gosudarstvennye prestupleniia (Basic Criminal Law of the Union of Soviet Socialist Republics), Articles, 1, 2, 12, and 13 and Zakon ob ugolovnoi otvetsvennosti za voinskie prestupleniia, Article 23, of Dec. 25, 1958, also cited in Ginsburgs and Rusis, op. cit., pp. 32–35.

[9] Testimony of William Colby, Director of Central Intelligence Agency, in U.S. Congress. Joint Economic Committee. Subcommittee on Priorities and Economy in Government. Allocation of Resources in the Soviet Union and China—1975. Hearings, 94th Cong., 1st sess., June 18 and July 21, 1975, p. 23. (Hereafter, Allocation, 1975.)

SOVIET SPACE SPENDING

Priority of Space Allocations

In 1975, former CIA Director William Colby testified in congressional hearings that Soviet defense and space spending had grown at a rate of about 3 percent per annum in the period 1960–73. As the overall Gross National Product (GNP) grew more rapidly, the share of GNP represented by defense and space fell from 10 percent to between 7 and 8 percent during that time period.[10]

CIA analysts viewed the Soviet space program as dominated by military objectives and unified in administration. They found that space expenditures rose from about 2 percent of total military expenditures in 1960 to over 11 percent by 1974 of total military space accounting for most of the increase. Based on these estimates (7 to 8 percent of GNP to defense and over 11 percent of defense in space expenditures), one could assume the CIA estimate of space to be just under 1 percent of GNP.[11]

The CIA estimates of Soviet defense and space spending were contested by intelligence analysts in the Defense Department.[12] They cited evidence that these activities were more likely to account for 10 to 20 percent of Soviet GNP.[13] These revisions appear to have been accepted by the CIA. One might have asked, in reference to the earlier estimates, how the Soviet Union did so much in defense and space with the estimated expenditures. Or how they were able to outspend the United States in most categories of defense and space with a comparable share of a GNP half the size of ours. An answer may be found in the method of costing Soviet programs and converting them to dollar values, allowance for variations in ruble-dollar conversions resulting from Soviet preferential pricing policy for defense and space, and possible understatement of full costs for defense-space programs such as adjustments might raise the defense share to 10 to 20 percent of their GNP.[14] If one accepts this higher estimate, the share devoted to the space program could be between 1 and 2 percent of current Soviet GNP.

The estimate of 1 to 2 percent of Soviet GNP, if correct, implies a space budget of $7 to $14 billion in 1974, and $14 to $28 billion in 1980. That estimate suggests a level of expenditures that is considerably larger than the present U.S. program and probably approximates (for 1974 in real terms) the U.S. space effort at its peak in the 1960's.

Later testimony by representatives of the intelligence community indicates that the proportion of the Soviet defense budget devoted to expenditures on space grew during the 1970's. Adm. Stansfield

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[10] Testimony of William Colby. U.S. Congress Joint Economic Committee. Subcommittee on Priorities and Economy in Government. Allocation of Resources in the Soviet Union and China—1975. Hearings, 93d Cong., 2d sess., Apr. 12, 1974, pp. 27-28. (Hereafter, Allocation, 1974.)

[11] Ibid., p. 28.

[12] Testimony of Lt. Gen. Daniel O. Graham, Director, Defense Intelligence Agency, in Allocation, 1975, pp. 93-94.

[13] Ibid., pp. 163-164.

[14] For a discussion of the problems associated with estimating Soviet defense expenditures, see Rainer W. Rupp. Assessing Soviet Military Expenditure: A Complex and Controversial Task. NATO Review, vol. 29, Oct. 1981; pp. 23-28.

Turner, CIA Director during the Carter administration, testified in 1979:

> We have closely monitored Soviet activities at weapons production and design bureaus, and today, we see no evidence that these economic difficulties have altered their momentum. They have about the same number of major weapon systems in production now that they have had each year since 1970. The mix is somewhat different. There seems to be more emphasis on space systems and systems incorporating advanced technology.
>
> This is a gross number that indicates how many missile programs—not their value, their cost or amount of labor or anything else—but how many missiles we know are under the development, how many aircraft, and so on.
>
> And as just a gross measure, we see it staying about the same.
>
> Senator PROXMIRE. What is the third category? You have missiles, aircraft, I can't read that next.
>
> Admiral TURNER. Space systems, ships, and submarines, et cetera.
>
> Senator PROXMIRE. Space systems are military applications of space?
>
> Admiral TURNER. Yes. That is primarily satellite systems and so on.
>
> These consistently high levels of activity have an important implication for growth in defense spending because new weapons systems like this always tend to be more costly than their predecessors, and particularly, as we move into very sophisticated areas like space and missiles.[15]

The official Soviet budget adds little to our knowledge of Soviet space and military expenditures. Soviet budget categories are probably incomplete, undoubtedly reflect preferential pricing for the space and military sectors, and, in any case, do not provide sufficient detail to separate space spending from other outlays. However, the general trend in the "science" and "defense" categories of the budget—which probably include most Soviet space expenditures—support the notion of a steadily growing space program. From 1955, 2 years before the first Soviet satellite, to 1965, the Soviet science budget grew more than fivefold (from 808 million rubles to 4.3 billion rubles).[16] It has continued to increase, though at a less spectacular rate, since 1965. (Since 1971, the science and education budgets have been combined. Consequently no separate totals are available.) The officially announced defense budget increased steadily in the 1960's and leveled off in the 1970's.

UNIFICATION OF MILITARY AND CIVILIAN SPACE

According to John Paisley, formerly of CIA's Office of Strategic Research, it is very difficult to separate Soviet military from civilian space expenditures. Still, he claimed, there is reason to believe that the military part dominates the Soviet program:

> We doubt that they have a program that splits the military and civilian. Most of the activities that we know appear to be carried out at military facilities. . .
>
> We think the most dynamic aspect of their program is the military at the present time.[17]

In response to Senator William Proxmire, in hearings before the Joint Economic Committee, former CIA Director Colby further explained the military domination of the Soviet space program on grounds of efficiency as well as priority:

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[15] U.S. Congress. Joint Economic Committee. Subcommittee on Priorities and Economy in Government. Allocations of Resources in the Soviet Union and China—1979. Hearings, 96th Cong., 1st sess., June 26 and July 9, 1979, p. 14.

[16] SSSR. Ministerstvo Finansov. Gosudarstvennyy byudzhet SSSR i biudzhety soyuznykh respublik; statisticheskiy sbornik. (State Budget of the USSR and Budgets of the Union Republics, Statistical Digest), Moscow, 1966, p. 21.

[17] Allocation, 1974, pp. 39, 28.

Mr. Colby. Now, you know, they have had a terrible time in their civilian space program, and they have had some very bad, bad experiences. I mean, a whole string of them have not worked. They lost the astronauts and they put things on various planets that have not worked, and all the rest of it. And we think, as a conclusion, that they put primary effort in the military arena, although their civilian space programs are given high public visibility.

Chairman Proxmire. In other words, they are including all of their effort in here, and the 2 to 11 percent increase, you think is very largely a military increase.

Mr. Colby. Yes, but a lot of it was construction of facilities that have dual purposes, and it is difficult to separate launch pads and things like that into military and civilian facilities.[18]

Dr. Malcomb R. Currie, when Director of Defense Research and Engineering of the Department of Defense, provided additional views on March 11, 1975.

> In recent years the Soviet Union has maintained an aggressive space program with its major emphasis on support of military operations. While definitive numerical comparisons of their expenditures with our own are difficult to make, we believe that the resources which the Soviets have put into their military space programs over the past three years are much greater than our own commitments.[19]

During the 1970's, U.S. military space programs accounted for approximately 30 to 40 percent of total U.S. space spending. Currie's testimony and comparison of the ratios or military to civilian satellite launchings suggest that the Soviet Union devotes a much larger proportion of its space budget to military applications than the United States.

THREAT OF AMERICAN INFERIORITY

The implications of the higher Soviet commitments and different space objectives were found by Dr. Currie to be a threat of American military inferiority within a decade.

> I believe that the Soviet effort right down the line in space has as its primary objective a superior military directed capability. Space is becoming a very pervasive part, as I mentioned of our national security, and of our military capabilities, and its transitioning right now from providing support strictly in a strategic sense to support also in a tactical sense. I would look forward a decade from now to the time when man in orbit will be able to enhance considerably our military capability and when satellite survivability must be given prime consideration in our programs.
>
> Certainly the demonstrations last year [deleted] show also that they are really proceeding down an independent path of research and development. They are no longer merely reacting to our demonstrations.[20]

Moreover, the programs in which the United States still retains leadership, such as the Space Shuttle with its rendezvous and docking capability, will become increasingly more vulnerable to Soviet military space capability in the Defense Department view. As the Soyuz-Apollo linkup may improve the Soviet capability to make our satellites more vulnerable, Dr. Currie implied the exchange program might further contribute to our vulnerability.[21] However, he did not argue that large military satellites would be less vulnerable than the Space Shuttle. The argument for the Space Shuttle is economy without a necessary increase in vulnerablity.

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[18] Ibid., p. 28.

[19] U.S. Congress. Senate Committee on Aeronautical and Space Sciences. Authorization for Fiscal Year 1976 and the Transition Period. Hearings, 94th Cong., 1st sess. February and March 1975, pt. I, p. 475. (Hereafter, NASA Fiscal Year 1976 hearings.)

[20] NASA Fiscal Year 1976 hearings, pp. 501-502.

[21] Ibid., p. 502.

BURDEN AND OPPORTUNITY COSTS OF THE SOVIET SPACE PROGRAM

DEFINITION OF BURDEN AND OPPORTUNITY COSTS

Perhaps the truest measure of the economic burden of Soviet space spending is a determination of the Soviet perception of opportunity costs. In other words, how much do Soviet decisionmakers value accomplishments in space compared to alternative economic goals that must be foregone? In order to maintain a large space program scarce resources—materials, machinery, scientists and technicians—must be diverted from other sectors of the economy. How important are those other sectors and how are resource allocation decisions made? Andrew Marshall Director of Net Assessment in the Defense Department, has noted this problem in assessing the burden of Soviet defense spending.

> What is critical is a better understanding of how that opportunity cost is perceived by Soviet leadership and society . . . To understand the burden of defense in any useful sense we need to know much more about how such conflicting and reenforcing views work themselves out in the Soviet system. The answer to this sort of question depends upon an understanding of the internal bureaucratic and organizational politics of the decision process which determine the allocation of resources . . . the perceived burden of defense may be increasing over time even though defense takes but a constant or declining share of GNP. Therefore, it is impossible to address the problem of the burden, or the Soviet perception of the burden, without knowing how strongly the Soviet leadership in general, or subgroups of it, are attached to some alternative goals that could be obtained by diverting resources from defense even if the efficiency of the shift of resources is low. Until much more progress is made in these broader dimensions of the burden issue, statements to the effect that the burden of defense upon the Soviets is great or small will not be persuasive.[22]

Thus, in estimating the economic burden of the Soviet space program, simple dollar estimates are insufficient. Unfortunately, we cannot determine Soviet perceptions of opportunity costs with great precision. However, our knowledge of Soviet "internal and bureaucratic and organizational politics" does provide a basis for determining whose perceptions of opportunity costs are most important. Moreover, various policy statements and official economic plans give some insights, if not hard evidence, of what priorities are attached to competing economic goals.

PARTY PRIMACY IN SPACE POLICY

Who decides or rules in the Soviet Union? In priority objectives, such as military and space programs, the dominant role is clearly played by the Politburo of the party's Central Committee and particularly by the General Secretary, Leonid Brezhnev. However, given the size and complexity of the Soviet scientific research effort in these areas, party leaders undoubtedly rely heavily on scientists for advice on funding priorities. In a speech to the Soviet Academy of Sciences, on the occasion of its 250th anniversary, Brezhnev described the interaction of the party leadership and Soviet scientists in planning and carrying out scientific programs:

> Scientists and specialists in the various branches of the natural sciences, technology and the social sciences have given and are continuing to give the Party enor-

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[22] Allocation, 1975, pp. 164-165.

> mous help in accomplishing all these tasks and in working out plans and implementing them. For this, the Party gives them all heartfelt thanks.
>
> However, comrades, in the future you will have to work even more, more persistently and more effectively. We have no intention of dictating to you the details of research topics and the ways and means of research—that is a matter for the scientists themselves. But the main directions of the development of science, the main tasks that life poses, will be determined jointly.[23]

Brezhnev's reference to "jointly" determining the directions of scientific research may be a euphemistic reassertion of the party's preeminent role in this realm. Yet, this moderate formulation probably reflects a growing role for the professional scientist in Soviet science administration. This development represents a gradual departure from the scientists' past subordination to the authoritarian demands or arbitrary whims of the party leadership.

The significance of an enhanced role for Soviet scientists is that their perception of opportunity costs must have some influence on party decisionmakers who establish economic priorities. Their preferences are weighed against those of other institutional groups, such as the military, industrial managers, and economic planners, by the party leadership, which makes the final decision on the broad allocation of resources.

How do Soviet scientists view the burden of the space program? While this question is not openly discussed in the Soviet press, there is evidence that there are highly divergent views. Some dissident Soviet scientists, like Andrey Sakharov, while not singling out the space program, have publicly opposed the general party line on resource allocations. Perhaps a more common view among Soviet scientists is that a disproportionate share of science funds are devoted to space. Soviet space scientists, Leonid I. Sedov, writing in 1971, supported large expenditures on space, while complaining that:

> One runs into the point of view that space research is a luxury and that the heavy allocations spent on it should be applied in the satisfying of the critical needs on Earth—the fight against hunger and disease, the development of education, agriculture, and so forth.[24]

This and other references to critics of the space program suggest that Soviet scientists have been active in asserting their views. However, the rising space budget is evidence that scientists who support the space effort have been most influential on the party leadership. Little has happened in recent years to suggest that party leaders currently differ from former Prime Minister Alexey Kosygin's assessment in 1965:

> We don't have any contradictions in the Soviet Union between appropriations for space research and for the needs of the population, or education and such. They are a negligible part of overall expenditure. Space expenses do not detract from the needs of the population.[25]

Thus budget-cutters have not had the same impact on Soviet space expenditures as in the United States. To some extent, however, the shape and content of the Soviet space program may reflect the various competing demands for the investment ruble. There has, for example, been an emphasis on minimizing the most expensive space activities, such as the U.S. Apollo program and manned flight in general. There has also been a concerted effort to emphasize programs with practical economic applications, though the Soviets appear to have been less successful than the United States in this effort.[26] Finally, there has been a strong preference for military space missions, suggesting that the priority assigned to space spending has in large part reflected the party leadership's perception of the military-strategic benefits of the space program.

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[23] Pravda, Oct. 8, 1975.

[24] Novoe Vremia (New Times), February 1971.

[25] Interview with James Reston, New York Times, Dec. 8, 1965, p. 20.

AN ONEROUS OR TOLERABLE BURDEN OF MILITARY SPACE

Various observers of Soviet behavior have made widely differing assessments of the political utility to the Soviet leadership of expanding military-space strategic systems. Two widely differing assessments, which might be characterized as the "Soviet superiority" school and the "diminishing marginal political utility" school, illustrate the range of options open to the Soviet leadership. The "Soviet superiority" school contends that:

> The Soviet Union has the capacity to expand military-space strategic systems to a level which assures strategic superiority over the United States in the near future. Such strategic superiority can be translated in Soviet political hegemony in various important geographical areas, including West Europe, Asia, and the Mediterranean. Thus, large military-space expenditures may promise such great political benefits that they will be unconstrained by the demands of hard-pressed civilian sectors of the Soviet economy.
>
> The "diminishing marginal political utility" school contends that: The incremental costs of new military and space programs have become so high and the political utility so low that stabilization or reduction of those priority programs is now considered desirable. In this context the tradeoff between new programs in military space and new civilian investment programs may even favor the latter. At least they would be considered as serious alternatives.

To be sure, these views are oversimplified to suggest the range in official U.S. political and intelligence assessments of Soviet leadership perceptions. The former school of thought, for example, approximates the views of some Department of Defense observers. A Defense Intelligence Agency document asserted for example:

> The expansion of Soviet strategic capabilities, combined with the limited value Western strategists generally accorded marginal advantages, has permitted the Soviets to achieve a nuclear force stature that canceled out long-held U.S. numerical superiority.
>
> The considerable momentum of Soviet nuclear weapons programs holds the promise of attaining a politically meaningful strategic edge.[27]

The "diminishing marginal political utility" school, on the other hand, comes close to former Secretary Kissinger's contention that, both we and the Soviet Union have begun to find that each increment of power does not necessarily represent an increment of usable political strength.[28]

If the "Soviet superiority" view were deemed accurate, the notion of burden, opportunity costs or tradeoffs between military-space programs and civilian investment would not seem very relevant. If military superiority were attainable and its fruits could be translated in meaningful political shifts in power relationships, the

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[26] CF. H. Kissinger "The defense establishment we have today is the product of decisions taken 10 to 15 years ago", speech before World Affairs Council at Southern Methodist University Mar. 22, 1976 entitled "Foreign Policy and National Security."

[27] "Detente in Soviet Strategy." Statement released by the Defense Intelligence Agency.

[28] Kissinger briefing to congressional leaders. Congressional Record, June 19, 1972, p. S9600.

Soviet leadership priorities would probably be clearly in favor of the traditional "guns" or military-space programs. However, if the latter perception of rising cost-diminishing utility is accurate, a reduction of relative military-space claims on resources is eminently logical.

Unfortunately, we do not have sufficient knowledge of the Soviet leadership's motivations to determine which of these views is closest to Soviet perceptions. Moreover, we might accept the absolute preference for military-space on quite different ground, that is, the Soviet leaders may consider themselves inferior and required to press ahead to attain their version of parity. Paradoxically, their view of their inferiority may be assessed in our military planning councils as superiority. This possible Soviet exaggeration of a need for defense against attack from the air may be reenforced by the Soviet concern about China which converted their traditional European ground invasion phobia through Germany into a revived two front threat.

OPPORTUNITY COSTS: MILITARY-SPACE VERSUS INVESTMENT FOR GROWTH

Assuming the high marginal cost-low political utility of military-space programs is the Soviet leadership perception we might consider what civilian options are at stake. In preparing for the Eleventh Five-Year Plan (1981–85), unveiled by party directives prior to the 26th Party Congress in February 1981, the requirements for increased investment may run well ahead of the anticipated annual GNP growth rate of about 4 percent, although actual allocations fall closer to the 2 percent rate.

Some of the pressing claimants for more investment are the following:

1. Development of Siberian oil and natural gas reserves.
2. Construction of the Baykal Amur railroad in the inhospitable sub-Arctic areas of East Siberia and the Far East, coupled with the expansion of materials output (timber, ore, et cetra) and industry in the regions opened by the railroad.
3. Expansion of the East Siberian hydroelectric based grid and related energy consuming industries, such as aluminum, steel, and copper.
4. Increased investment in agriculture to open the new non-black soil lands to cultivation and to provide more fertilizer and machinery to reduce the harvest losses and augment productivity.
5. Establishment of a modern animal husbandry system for expanded meat output.
6. Expansion of production facilities and infrastructure to permit the extended use of motor cargo transport and passenger car use.
7. Expansion of mechant fleets, tanker facilities, port facilities, and fishing fleets to meet transportation and food requirements.

It should be noted that these major objectives were very similar to those of the Tenth Five-Year Plan (1976–80), suggesting that military-space choices dominated growth objectives in the recent pool.[29]

Post-Stalin Soviet leaders have shown an increasing concern about progress in civilian industries, transportation and agriculture. Yet, even with a significant increase in the civilian share of investment funds, it will be difficult to meet the pressing needs of those sectors of the economy. Thus, it would seem clear that the opportunity costs of diverting resources to military and space programs should be very high for Soviet decisionmakers. However, if military and space superiority is deemed to be an attainable and desirable goal or defensive needs are overriding, the cost may be bearable.

It should be emphasized that the specialized, high-technology inputs of the Soviet space program are not easily convertible to civilian investment needs in the short run. Nevertheless, the difficult economic choices which confront Soviet leaders in the 1980's is likely to force them to reconsider all existing resource allocation patterns.[30] In such an environment, economic performance may well become a major issue in the inevitable succession process in Soviet leadership. Falling economic performance is of concern to all groups in the leadership, as well as the population as a whole. An "industrialization debate," such as influenced the succession to Lenin may not be precisely revisited, but every period of change seems likely to concentrate attention on vexing economic problems. A profound change in political as well as economic policy is possible in the wake of Brezhnev's exit from the scene. Moreover, the time of succession is likely to coincide with a period of potentially sharp deterioration in economic performance.

According to pessimistic U.S. intelligence estimates of energy and agricultural production and changes in the efficiency of labor and capital, the aggregate growth rate may be halved in the next decade to an average of little more than 2 percent, or less per annum in specific years with some years potentially evidencing negative growth. Others in the West with similar data conclude that a continuation of a 4-percent growth rate is an attainable expectation.[31]

While defense allocations have grown more rapidly than national income since the beginning of the Brezhnev era in 1965, real income per capita has risen and a respectable growth of industrial output has been achieved. In effect, the Soviets have been able to have "guns," "butter," and "modernization." But Soviet leaders must now choose. If defense spending continues as before, there will be shortfalls in civilian production and industrial manpower. A Wharton econometric study estimated that the incremental burden of defense procurement on the machine building and metal working industries would rise from a level of 35 percent during the current plan to 54 percent during the Twelfth Five-Year Plan, if the past trend in defense spending growth continues.[32] If military manpower is to be maintained at about 4.5 million men, with continuation of educational deferments, the civilian labor force will fall in absolute numbers after 1983.[33] These sharp increases in the incremental burden of defense procurement and military manpower will make the guns/butter/modernization choice more of a necessity in the 1980's.

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[29] Cf. Soviet Space Programs 1971-75, vol. II, p. 97.

[30] For additional discussion of future trends in the Soviet economy, see triannual compendia of the Joint Economic Committee, and Soviet Economy in a Time of Change; H. Hunter (editor), Future of the Soviet Economy, Boulder, Colo.: Westview Press, 1979. Earlier papers of the author given at NATO-SHAPE and the U.S. Military Academy were drawn on liberally. See J. Hardt, "Soviet Economic Capability and Defense Resources" in Grayson Kirk and Nils H. Wessell (ed.), The Soviet Threat, Myths and Realities, Academy of Political Science, New York, 1978; "Military or Economic Superpower: A Soviet Choice," in Senior Conference of U.S. Military Academy, Integrating National Security and Trade Policy, final report, June 1978, West Point, N.Y.

[31] Donald W. Green, "The Soviet Union and the World Economy in the 1980's: A Review of Alternatives," in H. Hunter, ibid., p. 42.

The sharp increase in the procurement burden is due to the projected slowdown in growth and the increasing cost of ongoing programs. The manpower crisis is the demographic "second echo" of World War II.[34]

MILITARY OR CIVILIAN SPACE

If Soviet space and military programs are to be slowed down, one might expect the military space share to retain or expand its portion compared to the civilian space programs, as has been the case in the past. However, if the U.S.-U.S.S.R. cooperative program is revived, its focus on civilian programs may provide an incentive for the Soviets to maintain their civilian program. In order to benefit from the American program and to keep the prestige of a proud scientific community intact, Soviet leaders may show an uncharacteristic preference for the visible, civilian program. If, then, the Soviet leaders were to move toward a cooperative US.-U.S.S.R. Space Shuttle program, the civilian space program might be among the higher priority claimants.

FUTURE PROSPECTS

The priority accorded Soviet space programs in the planning period ahead will probably depend primarily on the leadership's perception on the economic costs and political benefits of new programs. If considerable political gain is possible in the world arena, the high priority for military space will continue and even increase. If the gains are of questionable value in the international balance of power, the pressing claims of alternative civilian investment programs are likely to dominate. In that environment, serious negotiations as arms limitations seem more likely.

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[32] Daniel L. Bond and Hebert S. Levine, "The 11th Five Year Plan, 1981-85," Russia at the Crossroads. The 26th Congress of the CPSU," sponsored by the Rand Corp. and Columbia University and held on Apr. 23-25, 1981 in Washington, D.C., London, and Boston. Allen and Univim, 1982, pp. 103-106.

[33] Murray Feshbach and Stephen Rapawy, "Soviet Population and Manpower Trends and Policies," in U.S. Congress, Joint Economic Committee, Soviet Economy in a New Perspective: A Compendium of Papers Submitted to the Joint Economic Committee, (Washington, U.S. Government Printing Office, 1976), p. 150. Soviet military strength is now about 4.8 million men. The 4.5 million figure cited in the text is a conservative estimate of military manpower in the mid-1970's by Feshbach and Rapawy.

[34] Office of Senior Specialists and Foreign Affairs and National Defense Division, The 26th Soviet Communist Party Congress, CRS Report No. 81-203F.

Appendix I

Chronology of Soviet Space Forecasts 1975-80*

INTRODUCTION

Former reports covering the years 1966 through 1970 and 1970 through 1975 prepared for the Senate contained a chronology of Soviet space forecasts. Although the following chronology covers the years 1976 through 1980, information not available when the 1975 report went to press is reported. The purpose of this chronology is to gain insights on future goals and trends of the Soviet space program through the statements of Soviet officials, scientists, engineers, and cosmonauts.

1975

In an interview reported in Pravda, Academician R. Z. Sagdeyev and Prof. V. G. Zolotukhin commented on the importance of computers in the space program.

> *Question.* What are the principal uses of the electronic computer in space research?
>
> Answer. The first and most often practiced is determination of the parameters of the space equipment. Although this work essentially involves solution of the well-known problem of mechanics of the motion of a body, it nevertheless requires extensive computations of the optimization of trajectories and the determination of the orientation of a spaceship relative to the main axes.
>
> Recent years have seen the intensive development of the methods for mathematical modeling of complex systems. The modern spaceship serves as a typical example of such a system. The satellite-rocket combination is described empirically or theoretically by the obtained mathematical relationships and the computer is then used to check whether or not a unit, designed according to a particular plan, is properly performing.
>
> Still another direction is the direct processing of experimental results.
>
> *Question.* What problems urgently require solution for further extending the capabilities of the computer in space research?
>
> Answer. Modern computers have an operating speed of the order of several million operations per second. Their memory is designated for the storage of gigantic masses of information corresponding to millions of pages of printed text. However, even the most universal computer cannot efficiently solve the problems given it unless a number of additional steps are taken, the most important of which is a close association between the experimenter and the computer.
>
> It should be added that a computer operating in the space research field is subject to the same failings as all other computers. This bottleneck is in its servicing and repair. Every organization must have its staff of operators. But it is still impossible for every deficiency to be eliminated without outside help. At the present time a

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*Prepared by: Mrs. Charles S. (Jean) Sheldon, wife of the late Dr. Charles S. Sheldon II; Mr. Jeffrey Erickson, who was a graduate student intern in the Science Policy Research Division, from September 1981-May 1982; Mr. Christopher Dodge, a specialist in Life Sciences in the Science Policy Research Division; and Ms. Patricia Humphlett an analyst in Aviation and Space Sciences in the Science Policy Research Division, CRS.

centralized computer servicing agency is being organized, but it does not yet have enough specialists: they are being "snatched up" by the various ministries and departments.

With each passing year we gather more and more information from space, significant for basic research as well as many areas of the national economy. We must do everything possible to shorten the path between obtaining this information and using it for practical purposes. Electronic computer technology plays the dominating role here. (Translation: "Space and the Computer," interview with Academician R. Z. Sagdeyev and Prof. V. G. Zolotukhin; Moscow, Pravda, Nov. 13, 1975, p. 3.)

Reported in Pravda on November 16, 1975 Academician Keldysh evaluated the results of the flights of Venera 9 and Venera 10 as of outstanding scientific importance. He said these two vehicles represent a new generation of space vehicles, and although they have features in common with the stations which have been launched toward Mars, they differ fundamentally from them primarily with respect to construction of the descent modules. Keldysh also answered a question dealing with life on other planets and one on the importance of the study of planets of the solar system.

Question. What do you think about the existence of life on other planets?

Answer. The investigations which have been made indicate that there is no highly organized life on the other planets. Some hope still remains that very simple forms of life may be discovered on Mars. Our information on Martian natural conditions does not completely make it possible to exclude its existence. With respect to Venus, there is no possibility that life exists there, at least at the present time.

Question. What is the basic importance of study of planets of the solar system?

Answer. This is a necessary stage in learning about the universe which surrounds man, for a better understanding of our own planet. We are now witnesses of the onset of this stage. Space research provided us with qualitatively new possibilities for this purpose. The gradual accumulation of knowledge in this field is providing necessary data for solving one of the fundamental problems in modern natural science—the problem of the origin and evolution of the solar system.

The new and outstanding success in the study of Venus achieved on the threshold of the Twenty-Fifth Congress of the Communist Party is remarkable evidence of the creative genius of our people and a major contribution to the progress of all mankind. (Translation: "Automatic Apparatus Makes Studies," interview with Academician M. V. Keldysh; Moscow, Pravda, Nov. 16, 1975, p. 3.)

Prof. K. P. Feoktistov, the well-known space designer and cosmonaut, is quoted regarding the significance of the automatic docking of Soyuz 20 and Salyut 4.

Automatic docking is vitally necessary for the further development of cosmonautics. Visualize, for example, that a meteorite has penetrated the skin of a transport ship carrying cosmonauts to a station. In such a case the earth can send an unmanned ship on which the crew would be able to return to the earth. In the future orbital stations will have several docking units and unmanned ships can be used as freight rockets for delivering to crews working a long time in orbit both food and materials for scientific investigations, replenish fuel supplies and return to earth the fruits of the labors of the cosmonauts, such as motion pictures and still photographs and magnetic tapes. The experiment which is now being carried out is of great importance for the future of cosmonautics and we are happy that it is going successfully. (Translation: "Meeting with the 'Salyut'," by Boris Konovalov; Moscow, Izvestiya, Nov. 21, 1975, pp. 1, 3.)

In December, 1975, Boris Petrov, chairman of the "Interkosmos" council, and Burnazyan, U.S.S.R. deputy minister for health commented on the importance of cooperating in space research and providing for prolonged manned spaceflights.

The complex experiments carried out on the Cosmos-782 biological satellite, with the participation of specialists from Hungary, Romania, Poland, Czechoslovakia, USSR, United States and France, will assist the further consolidation of international cooperation, and will contribute substantially to improving systems providing for prolonged manned spaceflights. (Moscow, Domestic Service (in Russian), 2328 GMT, Dec. 22, 1975.)

1976

Several pages in the CPSU Central Committee Draft Directives for 1976–80 Five-Year Plan contain goals of a scientific and/or technical nature. One of these goals deals directly with space.

The continuation of the study and conquest of space and the expansion of research into the utilization of space facilities in the study of the earth's natural resources, in meteorology, navigation, and communications, and for other national economic needs.

Early in January Boris Petrov reported the coming of a new generation of Intercosmos satellites.

The socialist countries are switching to the use of a new generation of artificial earth's satellites—automatic standardized orbital stations, Academician Boris Petrov, who is chairman of "Intercosmos" council, told Tass.

Larger and more sophisticated, these satellites will enable to conduct [sic] more complex experiments under the "Intercosmos" programme, said the Soviet scientist. He reminded that [sic] nine socialist countries are taking part in the programme—Bulgaria, Hungary, the GDR, Cuba, Mongolia, Poland, Romania, the USSR and Czechoslovakia. Fourteen "Intercosmos" satellites were launched, as well as three "Vertikal" geophysical rockets and many meteorological rockets. Comprehensive space experiments have been conducted.

The cooperation, which is based on the principles of equality, covers space physics, biology and medicine, meteorology and communications, the scientist said. (Moscow, Tass (in English), 1557 GMT, Jan. 8, 1976.)

Academician Glushko gave a summary of the important work being done in the Soviet space program and at the same time commented about the development of long term orbital stations and about international cooperation.

The principal directions in the development of Soviet space research in the tenth five-year plan are associated primarily with many-sided investigation of the earth from space, exploration of circumterrestrial space and study of the nearest planets in the solar system. Investigations of earth from space have been exceptionally productive and their further development is a must. The mastery of near space has already made it possible to achieve much in the development of different forms of global communication and supplying our planet with meteorological information. The fundamental means for study and mastery of space is the creation of long-term orbital stations supplied with powerful research instruments. Crews working aboard these stations will not only study the earth and adjacent space, but will also carry out important astrophysical investigations. The crews themselves will serve as subjects for biomedical investigations. Prolonged presence of cosmonauts aboard a station will make it possible to perfect conditions for safe long-term work in space. Without solution of this fundamental problem there can be no talk of man's fully effective occupation of space. One of the principal tasks of orbital stations is carrying out extensive experiments in the development of new industrial processes using the unique conditions of space. The time is at hand to lay the basis for future space industry. In the more remote future we can think of the gradual development of industry and power production in space in order to safeguard our planet against the destructive influence of technical progress. In the new five-year plan we will continue exploration of the nearest celestial bodies—the moon, Venus and Mars, accompanied by a further development of international cooperation in space. (Summary: "Interview with Academician Valentin Petrovich Glushko"; Moscow, Zemlya i Vselennaya, No. 1, 1976, pp. 2–3.)

Leonid Brekhovskikh stated that satellites would be used for ocean research. Also, the purpose of the polymode experiment (with the Soviet Union and the U.S.A. as the main participants) would be to find out the nature of the huge vortical formations in the ocean, discovered by Soviet scientists in 1970. He continued by

saying substantial results should be expected from the first global experiment under the pigap program. (Moscow, Tass (in English), 1746, GMT, January 1976.)

In March, Leonov said that long-functioning orbital stations are the mainline of space research. Furthermore, he stated that the Soviet Salyut stations enable two cosmonauts to carry out a wide range of investigations and observations in the interests of fundamental and applied science and the national economy. (Moscow, Tass (in English) 1031 GMT, Mar. 31, 1976.) In addition, in April Petrov, head of the "Intercosmos"—the Council for International Cooperation in the Exploration and Use of Outer Space—revealed that cooperation was being mounted with Bulgaria, Hungary, the GDR, Cuba, Poland, Mongolia, Romania, and Czechoslovakia. An Indian satellite was shot up with the help of a Soviet rocket in 1975.

> As envisaged by the decisions of the 25th CPSU Congress, the Soviet scientists will continue exploring space and using space technology in studying the planet's resources, in meteorology, oceanology, navigation and communications, academician Petrov said at the end of the interview. (Moscow, Tass (in English), 1357 GMT, Apr. 9, 1976.)

Vladimir Shatalov writing about space navigation in the "new five year period" expressed the opinion that the limit of human endurance of weightlessness remains an important problem in space navigation.

> We do not yet know these limits, he wrote, but the length of time already undergone in weightlessness is sufficient for the exploitation of permanent orbital stations, which Soviet science considers the decisive factor in the mastery of outer space. The stations will make it possible to establish research laboratories in terrestrial space, for extensive research in geophysics, astronomy, astrophysics, biology, medicine, and space technology. The orbital stations will help mankind to master terrestrial space . . . the goal, that large collectives of experts worked hard to achieve, has been reached. An optimal scheme of space exploration with the participation of man has been found and is being successfully put to use. (Moscow, Tass, 1208 GMT, Apr. 9, 1976.)

Shatavlov continued to comment on manned flights.

> Why is it that in the field of manned flights Soviet cosmonautics is putting the main stress on creating long-lived orbital stations? It is because Soviet science regards them to be a decisive means for the broad exploitation of space. They are assisting us in organizing major scientific laboratories in circumterrestrial space for carrying out broad investigations in the interests of geophysics, astronomy, astrophysics, biology, medicine and space engineering. The stations will become orbital cosmodromes where experts can assemble interplanetary expeditions and spacecraft themselves. In the future there will be unmanned transport ships for delivery of freight to stations and for refueling them. Such ships will be able to return to the earth with scientific instruments for repair or replacement, with photographic, motion picture film and magnetic tapes. But there may also be transport ships of a different type which need not necessarily return to earth. Instead of a complex descent module there may be a container with supplies of fuel, water, food and other expendables needed for station operation. After delivery of the freight to a station such a ship will undock and burn up in the atmosphere. Such transport ships will be simpler, safer and less expensive. Progress in orbital observatories is more and more setting free the crews for collection of the information necessary for science and the national economy. During the tenth five-year plan Soviet cosmonautics will continue study and exploitation of space, broadening investigations with the use of space vehicles in studying natural resources, in meteorology, navigation, communication and for satisfying other needs of the national economy. (Abstract: "Fifteen Years in Space," by V. Shatalov, USSR Flier-Cosmonaut; Moscow, Aviatsiya i Kosmonavtika, No. 4, 1976, pp. 4–6.)

Continuing with the same theme, Georgiy Beregovoy, head of the Yuri Gagarin Cosmonaut Training Center, wrote for the Soviet Weekly Moscow News.

Making long-term predictions is unwise; cosmonautics has developed so quickly that it surpassed the most optimistic forecasts. But one thing is clear—huge complexes that can stay in a near-earth orbit for several years will be created. Crews will shunt back and forth on shuttle craft. There will be bases and camps on the moon. And in the more distant future there will be expeditions, first to Mars and then to other planets. (Moscow, Tass, 0835 GMT, Apr. 10, 1976.)

In May, 1976, there was a report of the progress of the cooperation of India and the Soviet Union that referred to an Earth satellite to study natural resources.

Soviet and Indian specialists are working to create an artificial earth satellite to study natural resources. Its launching is planned for 1978; writes the magazine of the USSR Academy of Sciences Zemlya I Vselennaya (Land and Universe). (Moscow, Tass in English, 0900 GMT, May 25, 1976.)

The future of communications satellites was given attention by Fedorov in July.

In accordance with the program for further development of the communication system and color television and the use of artificial earth satellites, during the past year a new type of space relay station was launched in the Soviet Union—the "Raduga" satellite, assigned the international registration designation "Statsionar-1." . . . , now space radio communication is occupying one of the leading places in the general system of communication means for the country.

And what if one looks to the morrow? How can one visualize the future of space communication? It is not altogether simple to answer this question. However, one prediction can be made boldly, without fear of falling into error: in the next decade the rate of development of space communication facilities will become truly astounding. (Moscow, Ekonomicheskaya Gazeta (in Russian), No. 29, July 1976, p. 24. Article by L. Fedorov, engineer, "Radio Bridges in Space".)

Also in July, the Intercosmos program was given attention in Pravda in a review of an article by V. Gubarev in which he stated "an automatic all-purpose orbital station . . . could appear above the planet in the next few months. A new generation of satellites is being born, and one intercosmos is currently passing the scientific baton to another." About the same time and on the same topic, B. Konovalov wrote:

The "Interkosmos-16" is the last in the series of small satellites. Henceforth automated universal orbital stations—satellites of the second generation—will be sent into space. They will be greater in weight and will make it possible to carry out broader many-sided experiments. The intergovernmental agreement of the socialist countries on cooperation in the investigation and utilization of space for peaceful purposes gives the "Interkosmos" program a new technical base. In the future we will see not only satellites, but also manned ships with international crews. (Moscow, Izvestiya (in Russian), July 29, 1976, p. 6 [Article by B. Konovalov, "Instruments Look at the Sun"].)

In addition, in August 1976, Izvestiya carried the text of an interview with V. S. Avduyevskiy in which he made the following forecasts regarding orbital stations.

The creation of orbital stations is the main path in the development of Soviet cosmonautics. Step-by-step we are bringing circumterrestrial space alive by means of these space laboratories. On the one hand, they enable us to carry out scientific, technical and economic investigations on a broad front, and on the other—clarify the possibilities of man in spaceflight and gradually increase the duration in space.

An orbital station is an ideal platform for carrying out astronomical observations. The progress of modern astronomy is determined primarily by an investigation of precisely those regions of the spectrum of electromagnetic oscillations which are absorbed by the earth's atmosphere. And in optical astronomy surface telescopes have evidently reached the limit of their technical possibilities.

Here the future is also linked to the mastery of space. Stations of the "Salyut" series have already carried gamma-ray, x-ray and IR telescopes. These investigations are very promising.

Question. In the immediate future will there be an increase in the size of orbital stations and the number of crew members and how will their appearance change?

Answer. Without question, as time passes orbital stations will become larger and more comfortable, but for the time being this remains an open question. In my opinion, at the present stage in the development of cosmonautics it would be undesirable to have larger stations. Indeed, we are now at such a stage when we are only defining the range of problems which can be delegated to space technology, a stage in which we are perfecting methods for interpreting the results of observations from space. Therefore, now it is evidently more advantageous to use relatively small, relatively cheap and at the same time modern stations of the "Salyut" type which afford a possibility for widely varying the scientific program and concentrating attention on individual highly important directions. (Moscow, Izvestiya (in Russian), Aug. 7, 1976, p. 2. [Interview with V. S. Avduyevskiy, "Month of Weightlessness"].)

A question concerning the prospects for the future utilization of orbital stations was answered by G. I. Petrov in an interview reported on September 3, 1976.

Modern orbital stations are designed for flight with a crew of two or three people. The high degree of automation of the apparatus on board and of the control systems enables them to conduct a considerable complex of experiments. The work of these stations, both in the piloted and in the automatic modes, amounts to many months.

In time, I suppose, it will become expedient to build stations designed for years and even decades of service with interchangeable crews comprised of 20 to 30 people. The probable development of super-large multi-purpose orbital complexes with crews of 100 or more people is in prospect.

Naturally, such stations will have to be assembled in orbit from sections and blocks brought from earth by relatively small rockets. Each section is conceived as a laboratory with a definite purpose with equipment which after the assembly of the station will go as a constituent part into the general power-supply and life-support systems. The most expedient geometrical shape of a standard station is the sphere or cylinders. As the sections of such a shape have the least weight for a given useful volume, are convenient to assemble, and they fit well into the contours of the carrier rocket. It is easy to impart the necessary configuration to a station assembled from cylindrical and spherical units.

As for assembly technique, it is not necessary to equip each unit with its own motor installation. The joining of individual sections will be undertaken, for instance, by a special flying assembly apparatus, something like a space tug-crane [oranbuksirovshchik], controlled automatically from earth or from on board the orbital station. Finally, a cosmonaut can also go over to it in order to effect manual control. After the main tasks have been completed, the space tug will be used for correcting the station's orbit and for the maintenance of its exterior. (Moscow, Pravda (in Russian), Sept. 3, 1976, p. 3 [Pravda correspondent's interview with Academician G. I. Petrov: "The High Road of Cosmonautics"].)

A report carried by the New York Times datelined Mosow, September 14, 1976 contained the following quotation.

"Astronauts from eight Communist-ruled nations will join Soviet fliers in space flights beginning in 1978," the official press agency, Tass, said, today. "They will orbit with the Russians in Soviet spaceships and space stations," Tass said.

According to Tass, dates were set during consultations here today to begin the training of future astronauts from Bulgaria, Hungary, East Germany, Cuba, Mongolia, Poland, Rumania and Czechoslovakia.

The eight nations together with the Soviet Union are members of Intercosmos, an association of Communist-ruled nations that has already cooperated in launching 16 unmanned satellites.

To date, Soviet and American astronauts have been the only men in space. The first man in space was a Russian, Yuri A. Gagarin, who orbited the earth in 1961.

The joint space flights will take place from 1978–83, Tass said. The astronauts will train at the Yuri Gagarin center near Moscow, where Soviet astronauts train.

Extended use of Orbita for ensuring television broadcasting to Siberia and telephonic-telegraphic communications to remote regions of the U.S.S.R. was announced in December.

The principal directions in development of the national economy of the Tenth Five-Year Plan provide for the broader use of artificial earth satellites, especially for ensuring television broadcasting to different regions in Western and Eastern Siberia and for telephonic-telegraphic communication with remote regions of the country.

During the Tenth Five-Year Plan, plans call for television broadcasting to reach virtually all the population of our country. Taking into account the enormous extent of the territory, today the only technically visible way to solve this problem is the transmission of TV programs to simple and cheap receiving stations which it is economically feasible to set in small cities and populated places. It is obvious that in this case it is mandatory to use geostationary relay satellites. (Moscow, Pravda (in Russian), Dec. 1, 1976, p. 3 [Article by M. Fedorov and G. Markelov: "Space Telebridge is Operating."].)

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The first manned mission of 1977 provided for joint work in orbit of "Soyuz 24" and Salyut 5. Shatalov stated that the possibilities of using orbital spacecraft and stations are "inexhaustible."

Air Force Lieutenant General Vladimir Shatalov, who was present at the launching, described the flight as a routine one. The possibilities to use orbital spacecraft—ships and stations—both for scientific and economic purposes are inexhaustible, he said. For instance, the program of "Soyuz-24" provides for joint work in orbit with the station "Salyut-5" that was launched nearly eight months ago. (Moscow, Tass (in English), 1730 GMT, Feb. 7, 1977.)

In March 1977, an Intersputnik agreement was signed in Moscow. One use of the system agreed upon was to be the transmission of the 1980 Moscow Olympics.

Agreement on cooperation was signed in Moscow today between Intersputnik, the international organization for space communications, and Oirt, the international organization for radio and television broadcasting. The agreement reflects the desire for expansion of the television and radio broadcasting exchange by using modern achievements in the field of communications, including artificial earth satellites. In particular, in the next few years, it is envisaged to expand the technical possibilities of the Intersputnik system, on the basis of deployment of multilayer satellites made in the USSR. These will be put on fixed earth orbit. Through these satellites, situated over the Atlantic and the Indian Oceans, along the Intersputnik system, it is envisaged that transmission will be organized of television and radio broadcasting programs from the 1980 Moscow Olympics. (Moscow, Domestic Service (in Russian) 1800 GMT, Mar. 11, 1977.)

A claim for the need for peaceful uses of outer space was made by Piradov at a session of the legal subcommittee of the U.N. committee.

Successes in space exploration become increasingly linked with the practical utilization of the achievements of cosmonautics for the purposes of economic, scientific and cultural development, i.e. for man's every-day needs. The achievements serve not only the peoples of those countries which directly conduct space research but all other peoples as well. Thus, the practical uses of outer space become property for the whole of mankind.

Aleksandr Piradov, representative of the USSR, emphasized in his speech at the session that it is necessary to do everything possible for outer space to remain an arena of peace, friendship and cooperation. "It appears important therefore that all countries adhere to the treaty of 1967 on the principles governing the activities of states in space. As is known, only 73 states have ratified the treaty or acceded to it," he said. (New York, Mar. 16, [1977] Tass.)

On the theme of international cooperation in space, Vereshchetin, deputy chairman of the "Intercosmos" Council of the Academy of Sciences of the U.S.S.R., wrote:

> International cooperation to one degree or other now covers the main spheres of space exploration and their practical application. Yet until recently this did not involve manned flights. The successful realization of the Soviet-American "Soyuz-Apollo" project has filled the gap.
>
> A new important step will be participation of citizens of socialist countries in manned flights aboard Soviet-made spaceships and stations.
>
> Our international cooperation in space exploration increasingly assumes a long-term nature. For instance, socialist countries elaborated for a long perspective, catalogues of problems for a joint solution, the scientist points out. There is a programme of long-term cooperation with France which covers many sections of space exploration. A possibility of further joint manned flights with the United States of America is being negotiated.
>
> As is noted in documents of the 25th CPSU Congress, space exploration is among the problems affecting the interests of the whole of mankind—the problem which in the long run will be exerting an ever more noticeable influence on the life of every people, the whole system of international relations. (Moscow, Tass (in English), 0600 GMT, April 12, 1977.)

In April, comments were made by Feoktistov concerning the development of cosmonautics in the near future and about the possibility of space settlements in an interview with correspondent V. Golovachev.

> *Question.* How do you picture the development of cosmonautics in the immediate future?
>
> Answer. Above all, the development of research and work in the interests of the national economy. Cosmonautics is already gradually becoming a sector of the national economy. Communications satellites play an important role. The meteor weather satellites are having a tangible effect. Work is being developed on monitoring the earth's surface from space. Surveys from satellites and orbiting stations in space, for example, help geologists in search of minerals, fishermen, agricultural workers, glaciologists, irrigators and specialists in many sectors of the national economy. . . . The direct "return" from cosmonautics can already be measured in tens and hundreds of millions of rubles. And this contribution will increase.
>
> In addition we are studying the possibility of carrying out various technological operations in space—obtaining superpure substances, semiconductors, crystals. . . . Such orbiting production may prove very important to the national economy in the future.
>
> I feel it is quite possible that at some time, perhaps within our lifetime, the construction of plants with unique technology will begin in space. It may be possible to put environmentally harmful enterprises into space—for example those enterprises which produce great quantities of heat (the problem of the earth's energy balance is very serious). . . .
>
> Another direction in the development of cosmonautics is research into circumterrestrial and circumsolar space and the nearest planets. That is, man must get his bearings in the environs of the home where he lives. This is chiefly a task for automatic machines.
>
> In my view, however, the most interesting results should be expected from investigating the universe. This is the third direction. This research will obviously be conducted both from onboard orbiting stations and in automatic astrophysical laboratories.
>
> To speak of design developments, there is the interesting task of creating large long-term orbiting complexes.
>
> Interplanetary ships will undoubtedly be constructed in the future. Man no longer feels himself simply an inhabitant of Earth but also of the entire solar system. It would be interesting, for example, to go into orbit around Venus and set up a station there for an in-depth study of this planet. . . . By that time, however, still more interesting ideas may have emerged.
>
> *Question.* And how do you feel about space settlements—small cities with a population between a few thousand and tens of thousands of people?
>
> Answer. Such settlements are possible in principle. There is no doubt about it. I believe they will appear in time. One of the possible reasons for their emergence will be if developing industry affects the biosphere on a menacing scale. . . . Who

knows, perhaps an increase of a few more percent in the carbon dioxide in the atmosphere will prove too much for the biosphere. And then the launching of production into space will be inevitable, and settlements too. I repeat: Technically this is, on the whole, feasible, and we know how to go about it and what to do. . . .

Of course, such a project would be incredibly costly. However, scientific and technical progress is now so rapid that even this problem may be resolved more quickly than it is possible to suppose today. What seemed fantastic yesterday is a firm part of our lives today. Look: Quite recently computers were considered a miracle of technology. But now schoolchildren frequently use a pocket calculator behind the math teacher's back. . . .

It would be expedient to construct space settlements quite far from Earth—at distances of the order of tens of thousands of kilometers. The delivery of materials to them and the installation of structures—all this entails great difficulties. . . . (Moscow, Trud (in Russian), Apr. 12, 1977, p. 3.)

A similar question was asked of Shatalov, and though his answer was essentially the same, it had a slightly different emphasis.

Question. Vladimir Aleksandrovich, how do you see the immediate future of cosmonautics?

Answer. Clearly other planets will for the moment remain the province of automatic craft. Manned flights will be around the earth and will increasingly be of specific practical benefit. The 25th CPSU Congress decisions directly show the way ". . . to continue the study and conquest of space, and to expand research for the employment of space means in studying Earth's natural resources, in meteorology, oceanology, navigation, communications, and for other needs of the national economy."

Manned ships and stations will work side by side with automatic satellites in resolving these tasks. The length of service of orbital stations will gradually begin to increase and their research potential will grow broader. Their work will be both automatic and manned. When cosmonauts are on board adjustment and repair work can be carried out on a broad scale, and the life of the station can be substantially prolonged.

Unquestionably international cooperation in space research must be strengthened and the number of countries participating in it must increase. Life has convincingly shown that space can successfully serve the welfare of all peoples on our planet. (Moscow, Izvestiya (in Russian), Apr. 12, 1977, morning edition, p. 2.)

In May, the United States and the Soviet Union announced an agreement on operating space stations in the 1980's. The announcement was made simultaneously by the National Aeronautics and Space Administration in Washington and the Soviet Academy of Science in Moscow. The story that appeared in the New York Times (May 18, 1977) follows.

The United States and the Soviet Union announced Monday an agreement to begin discussions that could lead to the operation of the first international space station sometime in the 1980's.

The announcement was made simultaneously by the National Aeronautics and Space Administration in Washington and the Soviet Academy of Sciences in Moscow. The agreement was negotiated in meetings between American and Soviet scientists in Washington last November.

Under the arrangement, space experts from both nations are to begin in the next month discussions along three lines: the feasibility of a large manned Soviet-American laboratory in earth orbit, ways to use the American space shuttle in such an operation and the types of scientific experiments and other operational aspects of such a mission.

N.A.S.A. spokesmen in Washington emphasized Monday night that the agreement does not bind either side to go through with such an endeavor.

"This is a feasibility-type thing with no firm plans other than to discuss such possibilities," the spokesman said in a telephone interview. "There's nothing in the agreement that says we're absolutely going to do this."

But it was a somewhat similar understanding that set in motion the negotiations and planning that led to the first joint manned space mission between the two countries in July 1975. In that earth-orbiting mission an American Apollo spacecraft, with three astronauts on board, linked up with the Soviet Soyuz, carrying two astronauts.

In considering future joint missions, American and Soviet space leaders are understood to have discussed the possibility of using the American shuttle, which is now under development, to ferry people and supplies to the Soviet Salyut. A number of Salyuts, which are small space stations, have been orbited by the Soviet Union in recent years and have been the centerpieces of most Soviet space activity in this decade.

Since the space shuttle is not expected to be ready for full operations until 1980 at the earliest, it is unlikely that the kind of joint mission being discussed would come about for four or five years, according to space administration officials.

Signing the agreement for the United States was Dr. Alan M. Lovelace, acting administrator of N.A.S.A., and for the Soviet Union, Anatoly P. Aleksanrov, president of the Soviet Academy of Sciences.

The following article on heat-regulating surfaces on spacecraft was abstracted in the May, 1977 issue of the Moscow University Herald:

The heat-regulating surfacings applied to the external surfaces of spacecraft are intended for maintaining a definite thermal regime of the spacecraft by establishing a balance between heat release within the ship, the energy absorbed by it from space and the energy re-emitted into space. The paper cited above gives a model of a heat-regulating surfacing of the enamel-ceramic type which has been damaged under the influence of fluxes of charged particles and a method is proposed for computing the change in the reflective properties of the surfacings. The authors discuss the limits of applicability and the errors of the proposed method. Conclusions are drawn concerning the possibility of computing the behavior of the spectral reflectivity of the heat-regulating surfaces in the process of their laboratory and field tests. It is shown that the method described here, within the framework of the adopted model, makes it possible to seek the absorption index for the surfacing on the basis of the experimentally measured values of reflectivity and to calculate the behavior of spectral reflectivity of the surfacings under the influence of corpuscular radiation. (Changes in Reflectivity of Spacecraft Heat-Regulating Surfaces, Moscow, Vestnick Moskovskogo Universiteta, Seriya Fizika, Astronomiya (in Russian), vol. 18, No. 5, 1977, pp. 15–24.) [Article by V. P. Borodulin and N. I. Karpov, Scientific Research Institute of Nuclear Physics, "Investigation of Changes in the Reflectivity of Heat-Regulating Surfacings of Spacecraft Under Influence of Corpuscular Radiation."]

In June, Georgi Petrov commented about multiple use space stations, exploration of Jupiter, and solar power stations.

Establishment of systems of multiple use of space equipment is one of the posssible trends of further development of cosmonautics, believes well-known Soviet scientist academician Georgi Petrov. In an interview to a Pravda correspondent, published in the newspaper today, he pointed out that multiple use systems may be particularly productive, combined with orbital stations aboard which man can work for some time, and then having taken exploration materials to return to earth.

To understand the origin of the sun is one of the main objectives of space exploration, the scientist believes. From this point of view, he said, it is particularly necessary to draw attention to the study of the solid substance scattered in the interplanetary space. Specifically, it is very important to get the undamaged primary substance of meteorites.

In the scientist's opinion, particularly close attention should be paid to exploration of Jupiter. It is a very important and difficult task to introduce a space vehicle into the atmosphere of Jupiter. Such an experiment for its significance could be compared with the historic voyages of the Soviet "Venus" automatic stations.

Speaking about the contribution of cosmonautics into scientific-technical progress, the scientist emphasized that space communication, space meteorology have already brought tangible practical results. Exploration of earth's natural resources from outer space is more confidently developing.

The use of energy resources of outer space is also quite feasible, Petrov said. Establishment of a network of helio-stations in the near-earth orbits and elaboration of methods of energy transfer to the earth with the help of a laser beam or a high-frequency emission open up fascinating prospects for the earth's energetics. (Moscow, Tass (in English), 0754 GMT, June 13, 1977.)

Remarks in an abstract of an article by R. Svoren dealt with attempts to establish contacts with extraterrestrial civilizations, and

included a comment regarding the progress in exoatmospheric astronomy.

At the Moscow House of Scientists there was recently a meeting with a group of scientists who told of different aspects of the problem of establishing contacts with extraterrestrial civilizations. Flier-Cosmonaut V. Sevast'yanov noted that during his spaceflight there were no evidences of extraterrestrial life; he also noted that American astronauts likewise failed to observe anything suggesting such life [despite rumors that they had]. A probabilistic approach to the question as to whether extraterrestrial civilizations exist was applied long ago, but unfortunately, during recent years nothing has happened which would make possible a more precise computation of the probability of the existence of reasoning life in the universe. It was noted that the progress in exoatmospheric astronomy can answer the question as to how frequently stars have planetary systems. Only one astronomer has reported the discovery of a star with a planetary system. And this is in the doubtful category. If it were possible to put a telescope with a mirror diameter of more than 2 m beyond the limits of the earth's atmosphere, it would be possible to see directly whether many stars in our microregion of the Galaxy have planets. One of the principal reports at the meeting was by N. Kardashov, a scientific specialist at the Space Research Institute. He told of attempts to pick up radio signals from other planets. Such attempts have been long ago undertaken in different countries using different radioastronomical systems and instruments. But the system which he described merits special attention. It was created specially for monitoring cosmic ether, in order to seek out ordered signals in space which with a high probability could be attributed to an extraterrestrial civilization. The basic idea is to use several receivers operating in the centimeter range, situated at very great distances from one another. For the time being three such receiving centers have been established: in the Caucasus, on Kamchatka and in the Pamirs. All the receivers operate synchronously and a signal is not considered to be received unless it has arrived simultaneously at all three receivers. And if a "rational" signal is received in such a spaced receiving system, it can be said with assurance that it is of nonterrestrial origin. [Article by R. Svoren', "Speculations With Hope."] (Moscow, Nauka I Zhizn' (in Russian), No. 6, 1976, pp. 63-65.)

Meteorological satellites continued to be praised in September. The direction of the use and the importance of these satellites was stated in an article by L. Aleksandrov carried in Izvestiya. Excerpts are given.

Since February 1967 the "Meteor" meteorological system has been operating in our country. Two or three "Meteor" satellites are constantly working in orbit; twice a day they scan our planet, transmit the collected information, which is used by our weather service and which after processing is directed to other countries. At the same time, we are using information received from American satellites. Now, in essence, a world weather service is being established which is making active use of meteorological satellites. Cooperation is intensively proceeding in the field of space meteorology, work being done by scientists of the socialist countries within the framework of the "Interkosmos" program.

The new direction in the use of satellites is intensively developing. The technical difficulties in the interpretation of space images are being successfully overcome. And there is no need to be a prophet in order to assert that in the years immediately ahead these investigations will pass from the stage of experiments into everyday, working practices. In addition to satellites of the "Meteor" type, use will be made of geostationary vehicles and meteorological satellites which will make possible regular and routine taking of photographs of the earth under identical illumination conditions. Mankind will soon receive an effective method for observing the state of the environment on our planet. These data can be used extensively in the national economy. This can give a maximum effect in the economy of the socialist countries. (Moscow, Izvestiya (in Russian), Sept. 30, 1977, p. 5.) [Article by L. Aleksandrov, "Weather Watch of the Planet."]

Two Soviet cosmonauts speculated on some future directions of the space program within the next decade. Particular emphasis was placed on the generation of electricity from space.

By the end of the next decade, in the opinion of some scientists, there may be an apparatus with an optical spectrozonal telescope and a powerful radar station for investigating natural resources and monitoring the environment. For investigating thermal processes, such as detecting the centers of fires, there will be a telescope with an IR detector. The center of a fire no bigger than an automobile will be registered in a few minutes regardless of the time of day or weather. Indeed, spacecraft parked in a stationary orbit can become the principal centralized system for monitoring the environment. Titov and Gor'kov continue with exposition of some ultra-advances which might be practical with respect to communication, navigation and the postal service, and then examine the possibility of using satellites for producing electric power. One such project calls for use of a large satellite with a mass of about 18,000 tons. Its solar cells would produce a power of 5 billion watts. It is not yet known how such a mass would be put into orbit or how the solar energy would be converted into electric power. Some propose use of solar cells, whereas others consider it desirable to create an apparatus with solar heating of the working body. Perhaps it would be put into a stationary orbit, since there the flux of solar energy is greater. Probably the creation of satellites for supplying power to the earth will proceed in stages as experience is accumulated in the assembly and operation of large-scale structures in space. Evidently, the first step will be the creation of a satellite for supplying electric power to other space objects. It will dock to the satellite-user or will transmit energy to several objects in the form of laser radiation. Then it will be possible to develop a larger scale satellite for supplying electricity to surface objects. Electromagnetic oscillations can be used for transmitting power over a distance. Scientists have long known how to solve this problem. Lasers have great capacity for uninterrupted transmission of energy to the earth. Another proposal is to use giant mirrors in circumterrestrial orbit for the reflection of the sunlight onto the night side of the planet. This could provide light exceeding by a factor of 10-100 the light of the full moon. Such a system can be of advantage in agriculture so that sowing and harvesting can be carried on around-the-clock. An artificial sun could also be created and this might increase agricultural production by 3-5 percent. (Some Future Possibilities in Space, Moscow, Aviatsiya I Kosmonavtika (in Russian), No. 10, 1977, pp. 20-22. [Article by Flier-Cosmonaut U.S.S.R. G. Titov and V. Gor'kov, "Glancing Into Future"].)

Nikolay Rukavishnikov, another Soviet cosmonaut, speculated on the future role of cosmonautics in the space program.

Cosmonaut Nikolay Rukavishnikov was asked the following questions. What new possibilities do spacecraft afford for scientific research in general and for investigations of the earth and its natural resources? What are the comparative possibilities of manned and automatic spacecraft in carrying out scientific investigations? What fields of specialization should a cosmonaut have for carrying out scientific experiments? What is the role of the creative activity of a cosmonaut in scientific research? How do spaceflight conditions influence the creative elements of scientific activity? What means can be used in increasing the efficiency of scientific research in space? His extensive remarks included the following. Very unusual possibilities are being afforded for use of optical telescopes in space. There is also no doubt that both manned and unmanned spacecraft will land on the surfaces of other planets. Studies of the earth's surface are and will yield the most immediate benefits to mankind. The earth as a planet can be studied, including its upper atmosphere, gravity field, continental drift and amount of received and reflected sunlight . . . The cost of constructing unmanned spaceships if far less than for a manned ship and they are more efficient, since the absence of a crew enables more instrumentation to be carried. For unmanned ships the surface control system need not be so complex. It is far easier to bear the loss of an unmanned ship than a manned one. Probably the best type of ship is one which is automatic but which is periodically visited for maintenance and for special research projects. Unmanned ships are indispensable for investigations where man cannot tread, such as on the surface of Venus. But there are instances when man is more effective than machine . . . With an increase in the number of participants on a space expedition there will be a special flight crew and a group of scientists who are specialists in their respective fields. At the present time the cosmonaut must be bifunctional. Even so, the results have been good . . . The creative activity of a cosmonaut is especially necessary in cases of experiments whose results cannot be foreseen, when during the course of the experiment there is a need for changing the method for executing the experiment . . . A major means for increasing efficiency in space work is a reduction in unproductive time spent in flight on the servicing of instruments and equipment. Control and servicing operations must be automated to the highest degree possible . . . (Role of Cosmonaut in Space Experiments, Moscow, Priroda (in Russian), No.

10, 1977, pp. 137-141 [Article by N. N. Rukavishnikov, "The Cosmonaut's Role in Space Scientific Experiments"].)

In October Pravda carried the text of an interview with R. Z. Sagdeyev, director of the U.S.S.R.'s Academy of Sciences Institute of Space Research. In examples of questions and replies that follow it is interesting to note his comments on the importance of basic research.

Question. In what direction, in your opinion, should the space effort be primarily directed, and what tasks should be resolved?

Answer. I believe that, as previously, the bulk of scientific research will be conducted in the earth orbits in which the first satellites flew. But we will gradually have to make the transition from individual experiments to comprehensive programs for fundamental research.

The most progressive path in research outside the limits of the earth's gravity has proved to be that of using automatic machines—the path begun by our Lunas, Veneras and Mars. By following it U.S. scientists have achieved success in studying Jupiter with the help of the Pioneer automatic stations and Mars with the help of the Viking apparatuses. At any rate in our century this method of studying the solar system will undoubtedly remain the most rational one.

Question. How broad must the front of planetary research be? Is it necessary, for example, to organize research as detailed as that which we conduct on earth on the Moon, Mars or Vensus?

Answer. I believe that we have not yet reached the stage in studying the planets, even those nearest to us, when we can raise the question of how far we should advance in their systematic investigation. Many unresolved problems still exist here.

In the first 20 years of the space age, flights to the Moon and the planets predominated to some extent. In my opinion, problems of investigating distant space with methods of satellite astronomy, which is only now taking its first steps, are also coming to the fore today. So far it has hardly provided any information on such objects, for example, as quasars. It seems that astronomical instruments, which will perhaps even surpass ground telescopes in terms of precision, will be working in orbit already in the next decade.

Question. What experiments in space strike you as most attractive?

Answer. Research in the x-ray and gamma diapasons of the processes taking place in the depths of the universe is of great interest. This hard electromagnetic radiation usually arises out of some kind of great cataclysm or explosion. As a specialist in plasma physics—plasma being the hottest state of matter—I am undoubtedly interested in how its extreme states are achieved in nature on a vast scale. We may encounter quite new phenomena here, which lie on the boundaries of plasma physics and gravitation theory.

Using circumterrestrial space as a giant natural laboratory, we acquire the possibility of conducting experiments with plasma. Here, in addition to investigating the processes occurring in the natural state, we can also create new ones with the help of artifical additives—for example, by "injecting" beams of charged particles. These experiments have been named active. They will undoubtedly be conducted widely in the next decade. For we have already learned how, by affecting locally particular sectors of the magnetosphere and ionosphere, to create processes similar to those which occur from time to time in nature and which are observed in the form of magnetic storms or polar auroras.

The possibility cannot be excluded that in the future mankind will be faced with the stern necessity of using such methods, for example, in order to insure the necessary chemical composition of the atmosphere. Problems already exist, such as the fall in the atmosphere's ozone content and, on the other hand, the increase in apparently secondary minor constituents which, as it turns out, play an important role in both the chemical and the radiation balance of our planet's air envelope.

Study of Jupiter's magnetosphere appears exceptionally attractive. It is like the earth's, but at the same time in terms of the strength of the magnetic field and the intensity of the radiation belts it resembles to a considerable degree the magnetosphere of pulsars—rapidly rotating neutron stars. Thus the interests of two sciences—circumterrestrial geophysics and astrophysics—merge here. (Moscow, Pravda (in Russian), Oct. 4, 1977, p. 3.)

The last question in this interview dealt with the opinion of Sagdeyev of the success of international cooperation in space research and his answer was that "globality—that inalienable property of space research—creates by its very essence broad preconditions for international cooperation."

In a speech given at a meeting to celebrate the 20th anniversary of the launch of the first Sputnik Academician Petrov said:

> Looking into the future, one can say that automatic devices in space, satellites and automatic stations will carry out more and more complex functions in research into space near earth, into links between the sun and the earth, the moon and the planets of the solar system, and will penetrate further and further into the reaches of the universe. Launches of biological satellites, both in the interest of working on fundamental problems of space biology and to resolve issues connected with the preparation for long manned space flights will continue. Orbiting stations will carry out long flights, receiving transportation vessels with crews of cosmonauts and unpiloted craft for delivery of cargo and supplementing reserves of fuel and life-support systems. (Moscow, Domestic Service (in Russian), 1405 GMT, Oct. 11, 1977.)

Tass International Service carried a story in Russian on October 24 that the building of a second generation long-distance laser satellite rangefinder would begin in 1978. The new rangefinder would operate in daylight while the present (1977) one operates only at night. "Such instruments are in operation at artificial satellite observation stations in the Polish People's Republic, the Arab Republic of Egypt, Bolivia, India, and Cuba."

An announcement made in December 1977, about the delta autonomous navigational system carried on Salyut 6. In an interview Valeriy Mikhaylovich said:

> The delta autonomous navigational system, as its name implies, makes it possible to determine the orbit directly on board the station itself without the participation of earth-based complexes and without the participation of earth-based radio equipment. This is what distinguishes the function of the delta system from the work of earth-based tracking stations. According to the measurements of altitude carried out on the station, the delta system itself determines the elements of the orbit without the participation of earth-based complexes. It does this autonomously. Moreover, it does so with a sufficiently high degree of accuracy.
>
> *Question.* Why is this necessary if the orbit is already known to earth?
>
> Answer. It is necessary so that in the future it may be possible to function without the work of earth-based complexes and to be able to completely determine the orbit with only the help of the delta system. . . .
>
> The delta system is now going through its final stages of development, and in the future it will be able to insure the automatic servicing of both the crew and the work of the station as a whole without resorting to the aid of earth-based resources. (Moscow, Domestic Service (in Russian), 1900 GMT, Dec. 15, 1977.)

Commenting on improvements in spacecraft technology, A. Pokrovskiy stated:

> On the present-day station the scientific equipment for conducting research in the field of astrophysics, the study of earth resources and technical and technological experiments was also renovated. The automatic flight system was also improved. And part of the equipment which was once experimental has become permanent. I have in mind, for example, the onboard teletype "Stroka," the system for regenerating water from the condensate of the station's atmospheric vapor, and the economical orientation system. (Moscow, Pravda (in Russian), Dec. 14, 1977, p. 2.)

Biological and medical experiments on Salyut 6 were elaborated on in December issues of Pravda and Izvestiya.

> On Friday, Romanenko and Grechko began three types of medical investigation which in the future will be repeated so that the physicians will have material for comparison. The bicycle-type erogmeter is not only a physical trainer, but also a medical instrument. Using this apparatus the crew during the medical investigation carries out tests with a carefully measured physical load. The cosmonaut spins the pedals with a velocity of 60 rpm for a period of five minutes. The loads are 750 kgm. By means of the "Polinom-2m" instrument it is possible to register and transmit to the earth data on the pulse rate, respiration, arterial pressure, data on the minute

volume of circulation, oscillations of the chest cavity due to cardiac contractions, etc.

Using this same "Polinom-2m" an electrocardiogram is registered for each of the cosmonauts from 12 leads, as under terrestrial conditions, in clinics.

The third type of examination which the cosmonauts began is a measurement of the volume of the lower leg. In space, due to the fact that "life is easy" (it is not necessary to overcome terrestrial gravity), there is some decrease in the volume of the so-called antigravitational muscles, especially in the legs. The physicians want to monitor this process. Depending on the data it is possible to recommend some intensity of the physical exercises which the cosmonauts have already begun to perform regularly. (Moscow, Izvestiya (in Russian), Dec. 18, 1977, p. 2. [Article by Boris Konovalov: "A Week in Space Orbit."]

Biologial experiments are continuing. The cosmonauts are observing the development of amphibians on board the station. The dynamics of the growth of Chlorella under the spaceflight conditions are being studied.

Tests are being conducted on the working capability of a device that monitors the effect of weightlessness on the kinetics of cell division in microorganisms. Using this device the first French-Soviet biological experiment on a manned space vehicle is being conducted. (Moscow, Pravda (in Russian), Dec. 27, 1977, p. 1.)

Worth noting was a story carried in the New York Times on December 27, 1977.

Moscow (UPI).—The lofting of two astronauts into space two weeks ago is part of a Soviet effort to set up a permanent scientific space station, Tass, the official Soviet press agency, said today.

The astronauts, Yuri Romanenko and Georgi Grechko, were sent into space Dec. 10 aboard Soyuz 26. They linked up with the Salyut 6 station, where they inspected malfunctioning docking equipment and walked in space.

"The aim of the work by the scientists and cosmonauts is not separate or unique experiments, but the establishment of a permanently functioning scientific watch in orbit," a Tass dispatch said. The agency said that Soviet space designers had been trying to create convenient and comfortable conditions aboard space stations.

"Salyut 6 is making in this sense a noticeable technological contribution to cosmonauts," Tass said. It said some of the key improvements have been a double-docking system allowing two simultaneous linkups with a space station.

Another improvement is an "automatic orientation system" that eliminates much of the tedious work of keeping the station on its course, Tass said, adding that life is not luxurious aboard Soyuz 26. Tass said that the astronauts' day was 15 hours, starting at 8 A.M. and ending at 11 P.M.

1978

The Soyuz 27 spacecraft and its crew was discussed in a January 10, 1978 Tass report.

Moscow, January 10, Tass.—Tass special correspondent Nikolay Zhelezhnov reports from the Baykonur space launching site:

The manned spacecraft "Soyuz-27" was launched from the Baykonur launching site today into an orbit close to that in which the scientific station "Salyut-6" with Cosmonauts Yuriy Romanenko and Georgiy Grechko on board, has been working for a month now.

The sixth Soviet orbital station which is now in orbit together with the "Soyuz-26" transport vehicle is in many ways an experimental spacecraft, said Air Force Lieutenant-General Vladimir Shatalov, one of the leaders of the Soviet space programme. New technical ideas will be tested during its flight. In particular, it is fitted with two docking units which permits of much more effective programmes of the expeditions. It opens up the possibility for the stations to operate simultaneously with two transport vehicles, a more reasonable and economical conduct of the operations to replace the crews, the provision of additional scientific equipment and food stocks for the expedition. Besides, as has been announced already, the Romanenko-Grechko expedition is provided with space suits to enable the crew to work in outer space for several hours to conduct preventive, repair and research work outside the space vehicle. (Moscow, Tass (in English), 1140 GMT, Jan. 12, 1978.)

Commenting of the future roles of space stations, V. Aksenov stated:

From the events of this fantastic evening I see a great and long road into the future. There will be permanently operating orbital stations with exchangeable crews. I see the work of cosmonauts for the needs of science and the national economy. (Moscow, Pravda (in Russian), Jan. 12, 1978.)

Earlier, Constantin Petrovich had commented on the future of the Soviet space program.

In response to the question as to how he visualizes the future of orbital stations, Konstantin Petrovich answers that first of all their main purpose as scientific laboratories will persist and be developed. Biomedical investigations will be continued aboard orbital stations in order to clarify how long man can spend in space without damage to his health. Investigation of the earth's natural resources from orbit will acquire ever-greater importance. Naturally, extensive use will be made of the unique possibilities of orbital laboratories for exoatmospheric observations of the universe.

With time technological experiments can lead to the creation of entire enterprises in orbit for the production of valuable substances and articles under conditions of a space vacuum and weightlessness. Orbital stations can become a base also for broader work in space. One of the promising directions is the creation of power plants capable of assimilating solar energy so abundant in space and transmitting it in transformed form for use on the earth. The dimensions of such power plants will not be reckoned in meters, but in kilometers; these will be structures which are enormous in comparison with present-day concepts. It is advantageous to put powerful solar electric power stations into a geostationary orbit at a distance of 36,000 km from the earth's surface. But economically it would be more advantageous to put them into low orbits, such as that in which the "Salyut" is flying. And then the plant could be towed in a definite segment of a geostationary orbit so that power could be conveniently transmitted to different regions on our planet.

Professor Feoktistov says: "The construction of special structures in circumterrestrial space for weather control can be extremely promising. Employing them it will be possible to use part of the solar energy which for the time being uselessly passes by our planet and use it for example in suppressing cyclones which are forming. This sort of structure will be of an enormous size and will weigh hundreds of thousands of tons. But the first step in their creation is orbital stations. The future is being laid today. (Moscow, Izvestiya (in Russian), Dec. 14, 1977.)

A January 14, 1978 Izvestiya article carried the following commentaries about biomedical work in space.

In one of the television communication sessions we saw "Pamir-1"—Vladimir Dzhanibekov, shrouded in wires from different sensors and motionless in the "Chibis" suit. The suit consists of pants with an attached top. The suit is put on the lower half of the body, is sealed and a reduced pressure is created. Because of this the blood from the upper half of the body seemingly is forced into the lower half of the body and this for a definite time simulates the conditions of terrestrial gravitation. A comparison of the picture of distribution of the blood in a cosmonaut during ordinary exposure to weightlessness and with creation of reduced pressure in the lower half of the body gives physicians a possibility of judging how the adaptation process is going and what changes it causes in the cardiovascular system. (Moscow, Izvestiya (in Russian), Jan. 14, 1978.)

On January 16, 1978, Tass carried the following account of the Salyut 6 complex comprised of three space modules.

Moscow, January 16 Tass.—A research complex consisting of three spacecraft has been established in orbit for the first time, General Valdimir Shatalov writes in the newspaper Vozdushnyy Transport (Air Transport) about the link-up of two Soviet piloted spaceships of the "Soyuz" type with the orbital scientific station "Salyut-6".

General Shatalov, who is in charge of the training of Soviet cosmonauts, says in the newspaper that for the first time the Soviet cosmonauts had to assemble in orbit a unique system of three objects that were put into orbit at different times. From the technical point of view, the specialists were interested in the way the joined elements would "behave themselves" in such a big dynamic system. The entire complex was about 30 metres long and weighed over 32 tons. Hence, the loads on the joined elements were rather great.

"The establishment of a new orbital complex is not just a matter of increasing the mass of a space system, not just a matter of increasing artificially the useful volume or the number of crew members," the article says. "We take a broader view of the problem. Practically this is a new step in the exploration of outer space with the help of manned ships, a step opening up beckoning prospects."

Thus an opportunity has been created for replenishing the supplies of an orbital station, for supplying it with fuel, oxygen, food, photo and cine facilities, scientific and technical equipment. This can be done with the help of transport ships, manned or unmanned.

Moreover, it is possible to take from board the station in orbit some materials which have to be immediately processed and analysed on the ground before some decisions are made, or to take to the station raw materials for staging technological experiments and return final products to earth. In this way we can select some material for analysis on the ground without interrupting the program in hand, Vladimir Shatalov writes.

Usually, all the scientific apparatus required for a space mission and all supplies go to outer space aboard the station. This means that the station has to carry a maximum payload. Now we can revise our views as to the supplies the station has to take to outer space. We can arrange the transportation of apparatus and supplies to the orbiting station, when necessary, and thus make room for the more important sophisticated equipment on board. Moreover it will be possible to send to the station "narrow" specialists for staging some local experiments and then quickly returning to earth.

What is also important is that this experiment creates an opportunity for improving considerably the efficiency of scientific apparatus. Ideally instruments should operate round the clock. But two men on board cannot conduct continuous observations, say, of meteorological conditions on earth and weather data for fishermen and fliers, geologists and builders. The presence on board of another crew would help increase the observation time considerably. (Possibilities Arising From Salyut-6 Complex Explained, Moscow, Tass (in English), 0935 GMT, Jan. 16, 1978.)

The joint Soviet/French biological experiment "Cytos" was described in a January 14, 1978 Tass report. It was mentioned again in a January 15, 1978 Izvestiya article.

The joint biological experiment "Cytos" is being conducted on board the Salyut-6-Soyuz-26-Soyuz-27 space complex.

Professor Nefedov said a capsule with micro-organisms in a container worked out by Soviet designers was brought to the orbital station by Vladimir Dzhanibekov and Oleg Makarov on board the Soyuz-27 spaceship. On board the station the capsule was transferred to the "Cytos" instrument devised by French scientists and designers. A French thermostat makes it possible to permanently maintain an optimum temperture set by biologists.

Scientists of the two countries are very much interested in carrying out this experiment, since it will help study the effect of space flights factors on the kinetics of the cell division of micro-organisms, Nefedov emphasized. The experiments will give an opportunity to determine in a more accurate way the effect of space weightlessness and radiation factors on the organism. The experiment is also of much importance for understanding the processes of the growth and propagation of microbes in space flight conditions. (Moscow, Tass (in English), Jan. 14, 1978.)

"The objective of this experiment," stated the work director on the Soviet side, Professor Yu. G. Nefedov, is to trace the dynamics of development of living cells under spaceflight conditions. As the objects for investigation Soviet scientists selected Proteus cells (their "cousins" have already been in space more than once), whereas the French colleagues headed by Professor Planel of Toulouse University selected a different representative of microorganisms—Paramecium. We hope to clarify whether space conditions exert an influence on the cell level. (Moscow, Izvestiya (in Russian), Jan. 15, 1978.)

Cosmonaut General Georgiy Beregovoy speculated on the development of permanent space stations with rotating crews as a result of the Salyut 6/Soyuz 26 and 27 program.

Moscow, January 18, Tass.—"The flight of the Salyut-6-Soyuz-26-Soyuz-27 orbital complex and the successful return of the visiting crew—Cosmonauts Vladimir Dzhanibekov and Oleg Makarov—back to earth are a new stage in the development of soviet cosmonautics," Cosmonaut Georgiy Beregovoy, head of the Yuriy Gagarin Cosmonauts Training Centre, told a Tass correspondent. He emphasized that the experiment is a major step towards creation of permanently functioning orbital stations with replaceable crews.

The crews of two spaceships, four cosmonauts, worked for five days on board the "Salyut-6" space station for the first time in the entire history of cosmonautics, General Beregovoy said. Important scientific research and medico-biological experiments have been carried out.

The availability of two docking units at the orbital station will make it possible to carry out shuttle operations, General Beregovoy said. The second docking unit opens up a prospect of making freight expeditions, delivering new research instrumentation to the station and replenishing food stocks as well as promptly transmitting scientific data back to earth.

Georgiy Beregovoy pointed out that there are still a good deal of problems on the way towards creation of orbital stations with replaceable crews, where scientific laboratories with tens of people will be functioning. "After Vladimir Dzhanibekov and Oleg Makarov returned to earth, the people in orbit became closer to us as if a great opposition occurred: at any moment the earth can come to the aid of its cosmonauts," he said. (Cosmonaut Training Chief on Importance of Salyut-6 Mission, Moscow, Tass (in English), 1432 GMT, Jan. 18, 1978.)

Photography conducted from Salyut 6 was discussed in January 20, 1978 Izvestiya article.

And now, indeed, these prospects have become a reality. Yuriy Romanenko and Georgiy Grechko have begun photographing the earth with the MKF-6M from the long-term "Salyut-6" orbital station.

"Whereas the work of the cosmonauts aboard 'Soyuz-22' was fundamentally of an experimental and scientific character," said Ya. Ziman, Department Head at the Space Research Institute USSR Academy of Sciences, to the reporters, "it was decided to devote 90 percent of the picture taking on this flight to the needs of the national economy and only 10 percent to scientific research. Since every space photo is of interest to many branches of the national economy the information from space will be processed as needed by the 'Priroda' State Center and distributed to all interested parties for practical utilization."

Photography in different parts of the spectrum supplies additional information about the optical properties of the atmosphere and its pollution. It also has its own "depth vision" due to the fact that it photographs reflected solar radiation of different wavelengths which penetrates water to different depths. Thus, the pictures of Lake Baykal taken from "Soyuz-22" traced in depth the confluence of waters from the Selenga River and the lake. On the surface, the water was clean, but the other five levels revealed that the waters of the Selenga River bring into Lake Baykal pollution which increases with depth. (Moscow, Izvestiya (in Russian), Jan. 20, 1978, p. 4. [Article by B. Konovalov: "Rainbow Over the Planet"].)

Several commentaries on the automatic transport spacecraft Progress 1 appeared in the Soviet press in late January 1978.

The automatic spacecraft, which was designed on the basis of the Soyuz spacecraft, is intended to carry out transport operations to provide for the long-term functioning of orbiting scientific stations.

The aim of the launch of the Progress-1 spacecraft is to carry out tests and the integrated development of the design of onboard systems and equipment of the new automatic transport spacecraft; to carry out a docking with the Salyut-6-Soyuz-27 manned orbiting complex; to deliver on board the complex fuel for the motor installation and various cargo and also equipment apparatus and materials to provide for the life and activity of the crew, and to carry out scientific research and experiments. (Moscow, in English to South and Southeast Asia 1100 GMT Jan. 21, 1978.)

"Our science correspondent" has asked Dzherman Titov for details about the Progress-1 spacecraft.

The automatic freight transport ship has been made on the basis of the Soyuz manned spaceships, said Dzherman Titov. It differs from the manned version by its fully automatic operation. After delivering its cargo to orbital stations the Progress-1 does not return to earth. Since it has no descent or landing systems this has made it possible to increase its carrying capacity. The job of Progress-1 is to supply cosmonauts for prolonged stays in space. "There are already designs for large extraterrestrial settlements, (?industrial) orbital stations and interplanetary terminals. Even a new term, astroengineering, has come into use, Dzherman Titov pointed out. Astroengineering involves the construction of large complexes outside the earth. A very serious discussion of practical projects has begun over the past few years. Yet they can be put into effect only if the (?earthmen) learn to make and operate long-duration orbital stations. These stations should be able to receive freight transport ships many times and to carry out a wide range of scientific and technological problems. Progress-1 is the prototype of the freight transport ship of the future. (Progress-1 Launched, Moscow, Tass International Service (in Russian), 1337 GMT, Jan. 20, 1978. Moscow—The Progress-1 automatic transport spacecraft was launched in the U.S.S.R. today.)

Under the programme of the flight; the members of the crew will carry on board the station the cargoes that were delivered and will carry to the transport ship the equipment that was used up. Operations for refueling the station will be carried out on command from the flight control centre and also directly by the crew.

To increase the capacities for bringing cargoes into the orbit and to cut the cost of transportation operations, the ship Progress-1 has been designed in such a way that its return to the earth was not envisaged.

After operations in the orbital scientific research complex are concluded, the ship Progress-1 will be separated from the station. It will enter dense layers of the atmosphere and will be burnt up. (Moscow, Tass (in English), Jan. 22, 1978.)

At noon today a cargo express approached the unoccupied docking unit of the Salyut-6 orbital station. This is the first flight of a new pilotless spacecraft, "Progress-1", which opened regular communication along the "earth-orbit" route.

This expedition is in many respects experimental. First of all, put to trial is a second-generation station opening new opportunities for replacing crews. The idea of constructing complex engineering units in orbit is in fact being put to trial. The task of the automatic cargo express is to blaze the trail for a reliable cargo bridge to ensure a years-long operation by orbital stations.

The "Progress-1" is intended to breath new life into orbital exploration programs, to make them more profitable, to raise the quality of orbital research in the interests of science and the national economy of the U.S.S.R. (Moscow, Tass (in English), 1639 GMT, Jan. 22, 1978. Moscow, January 22, Tass—Tass special correspondent Nikolay Zheleznov reports.)

If one calculates them carefully, the "consumables" on the station comprise 20-30 kilograms a day. To carry supplies, for example, on a Soyuz with cosmonauts for two or three months of work would be complicated. And if for a year? In that case it's already 10 tons. It's impossible to do without a cargo transport craft such as Progress. (Moscow, Pravda (in Russian), Jan. 23, 1978.)

(Yuriy Koltsov), a scientific employee of the USSR Academy of Sciences has commented on yesterday's Progress-1-Salyut-6-Soyuz-27 docking feat. He says that if one could take a close look at the space complex, one would find that Progress-1 outwardly resembles Soyuz-27. Indeed the automatic transport craft was created on the basis of the manned Soyuz craft. However, the crafts' different purposes determine the differences in their construction. What is Progress-1 like? Like Soyuz, it consists of three sections [otsek]. Only one of them has retained its former name as the propulsion unit-instrumentation section [priborno-agregatnyy]. This section has undergone substantial changes. The propulsion unit [dvigatelnaya ustanovka] remained in it but automatic instruments were added.

Progress-1 has no descent module. Instead it has a fuel section in which fuel and the oxidizer [okislital] are brought up to the station. Modern orbiting stations such as the last Salyut, or the American Skylab, can operate in space fairly long. However, stores of food and water run out.

Chemical substances exhaust their capacity for restoring the atmosphere. Fuel is used to execute various maneuvers. More and more things that were once useful are turned into waste. For instance, 20-30 kilograms of various materials and substances are turned into useless cargo on the Salyut-6 every day.

Over the years kilograms turn into tons. The time comes when you have to part with the station forever, though all its systems are fully operational. All that has to be done is to renew the stores, this is why Progress-1 was created. Apart from fuel, hundreds of kilograms of various cargo were brought up to the station. They are situated in the third section—the cargo section. It is practically a space warehouse; it has many shelves. New scientific instruments are here, as are cassettes with belts for the on-board scientific instruments; there are balloons with water and new regenerators to maintain normal atmosphere in the station; there are receptacles [yemkost] for collecting various wastes and ejecting them into space; and there is a fresh change of linen and toilette paraphernalia. (Moscow, Domestic Service (in Russian), 0830 GMT, Jan. 23, 1978.)

Moscow, January 24, Tass.—In accordance with the programme of the exploration and use of outer space the Soviet Union launched an artificial earth satellite "Cosmos-954" into orbit around the earth on September 18, 1977. It carried aboard a small nuclear nonexplosive unit intended as an energy source for the instruments on board. The energy unit was designed in such a way as to be fully destroyed and burnt in entering the dense layers of the atomosphere.

In the course of the satellite's flight outside the zone of radio-visibility of the Soviet tracking facilities it was sharply depressurized for reasons yet unknown on January 6 this year, with the result that the satellite began to come down in an unplanned regime. [Moscow Tass International Service in Russian at 2020 GMT on 24 January renders this phrase in Russian "nezaplanirovanym rezhime".]

According to the coordination computer center which kept constant track of the flight the "Cosmos-954" satellite entered the dense layers of the atmosphere over northern Canada and ceased to exist in the afternoon of January 24 this year. (Moscow, Tass (in English), 2028 GMT, Jan. 24, 1978.)

The unexpected reentry of Kosmos 954, a Soviet satellite with nuclear materials aboard received the following coverage in late January 1978.

Zbigniew Brzezinski, the U.S. President's national security adviser, confirmed in Washington today the statement issued by the Canadian Government that a small Soviet satellite with nuclear propulsion had come down in the area of the Great Slave Lake in northwest Canada. At a press conference he asserted that what was involved was a special satellite of the Cosmos series intended for military purposes. He also stated that two U.S. aircraft had been sent to the area where the satellite dropped to ascertain whether the fall had caused any contamination of the area, but he stressed that the danger from radiation was minimal. (Zagreb, Domestic Service (in Serbo-Croatian), 2100 GMT, Jan. 24, 1978.)

["The Day is Over" program, with Jan Zakrzewski and Jacek Maziarski]

[Zakrzewski] We have before us a communique published by Tass today.

On the afternoon of 24 January, the sputnik Cosmos-954 entered dense layers of the atmosphere over northern Canada and disintegrated. On 6 January during the flight of this satellite outside the range of radio-communication, due to so far unexplained reasons, a sudden depressurization occurred causing the sputnik to lower the trajectory of its flight. In accordance with the program of exploration and use of outer space, the sputnik was launched on 18 September 1977 into orbit around the earth. It had onboard a small nuclear unit which was nonexplosive and was designed to power the equipment on board. The design of this energy unit was such that its full destruction and disintegration would be triggered by entering the dense layers of the atmosphere. So much for the communique.

[Maziarski] The sputnik which burned out today is numbered 954. Also today we saw the launching of Cosmos-986. Let us recall that the first Cosmos was launched on 16 March 1962. Recently Cosmos satellites were being launched at about weekly intervals. Their mass varies between 0.5 and 1.5 tons. What is their purpose? The answer to this question is secret, but it is well known that among other things they are engaged in meteorological research, in experiments in the upper atmosphere. It is also well known that the Cosmos satellites are capable of being recovered. The duration of the flight of Cosmos satellites depends on their orbit. Those which were placed in circular orbits round the earth in 1965 remain there for about 1,000 years. (Warsaw, Domestic Service (in Polish), 2000 GMT, Jan. 24, 1978.)

In a question/answer session, two cosmonauts from Salyut 6 discussed the manned space program in general.

[Special correspondent G. Lomanov report from flight control center: "At the Svezdnyy Mooring"]

NEAR MOSCOW.—You do not need to be an expert to appreciate the scale and intensity of the present space program. Never mind the specialists, even we journalists have long since forgotten that some of the days on the calendar are printed in red. On Saturday in Svezdnyy Gorodok we met with V. Dzhanibekov and O. Makarov who had completed their space journey and on Sunday morning we rushed to the flight control center for the docking of the Progress-1 transport spacecraft with the space station.

Immediately after the spacecraft was launched we asked Doctor of Technical Sciences and Pilot-Cosmonaut K.P. Fektistov to comment on the latest stage of the program—the inauguration of a freight route to Salyut-6.

"Even when work on the creation of long-term orbital stations was only beginning we realized that sooner or later freight routes would have to be laid in space," Konstantin Petrovich told us. "Now this time has come. In the future, when the number of crews and the duration of their work on the stations increases, the flow of freight on the earth to orbit route will increase correspondingly.

Why are transport craft of the "Progress" type needed? To answer this question let us look at all the "items of expenditure" which we cannot do without during work on an orbital station, there are hundreds of instruments and apparatuses on Salyut-6 and if you consider individual units and assemblies the number rises to thousands. The more components there are, the greater the likelihood that one of them will go out of commission—this is one of the rudiments of reliability theory.

During a long flight the need invariably arises to replace several assemblies and that means that new ones must be delivered on board.

From time to time it is necessary to correct the orbit of Salyut-6 and make it more convenient for the next craft to dock. Fuel is expended on corrections and other dynamic operations and it must be replaced. The cosmonauts throw garbage and waste into open space through the air lock. The operation of the space-borne "garbage dispoal chute" involves losses of a certain proportion of the atmosphere through the air lock. Grechko and Romanenko have been out into open space to inspect the docking unit—more losses. After all, on long flights such operations involving external inspection of the station and preventive work on it are inevitable. While on earth transport workers are usually criticized if they "transport air," in space this is perfectly valid freight."

Question. But all the same, it does sound very unusual: "A cargo of atmosphere and the cargo recipient the orbital station crew."

Answer. Yes, on earth such an item on the invoice would be considered at best unproductive. But Progress-1 will in fact supply Salyut-6 with gases forming the components of the station's atmosphere. A very large item of expenditure is connected with the operation of the life support system—it is essential to change the regenerators, carbon dioxide absorbents, the harmful impurity filters and so forth regularly.

The transport craft is also needed to provide materials and equipment for the scientific research program. After all, far from everything can be unloaded onto the station at once or sent into space when it is launched. Take just the biological material for the "Tsitos" experiment—it cannot be kept for more than 5 days. Another example: A great deal of film is used during the operation of the multiple zone [mnogozonalnaya] MKF-6M camera. It is impossible to take a large stock of film in advance-cosmic radiation, the so-called galactic background, will, over a protracted period, spoil the film by exposure.

Question. Konstantin Petrovich, you once remarked that it was still premature to speak of comfort, in the usual sense of the word, on board the station. Nonetheless, with every passing year the number of everyday comforts on board orbital stations is increasing—now there is even a shower. Obviously this also adds further items to the list you have given?

Answer. Undoubtedly. Water is needed for the shower, and towels, sanitary wipes [gigiyenicheskiye salfetki], and so forth. Very mundane, but extremely necessary items, are needed. For instance, underwear. In the "flight" against weightlessness the cosmonauts have to sweat a lot on the exercise machine and they have to change their underwear quite frequently. In a word, to total up all the "items of expenditure" in a day they amount to 20–30KG. Simple arithmetic shows that in a month this adds up to almost a ton and in a year to about 10 tons. It is perfectly obvious that it is irrational to load such a mass of freight on when the station is launched and indeed it would simply be hard to find room for it.

Question. One last question, Konstantin Petrovich: Progress-1 has been created on the basis of the Soyuz. What distinguishes the freight-carrying version of the transport craft?

Answer. Since there is no crew on board the Progress-1 the living compartment is unnecessary and it is replaced by a freight compartment. Racks have been installed here on which the baggage we send to Romanenko and Grechko is fixed. The craft is controlled by automated equipment and therefore the instrument compartment has been somewhat enlarged and additional systems have been installed in it.

To simplify the structure as much as possible and if possible make it cheaper, we do not provide for Progress-1 to return to earth. After it has undocked it will gradually descend and enter the dense layers of the atmosphere and burn up. Therefore, there is no reentry vehicle on the craft and no parachute systems or thermal protection are needed—and they would amount to a considerable weight. Instead we have installed a compartment containing tanks carrying fuel for the Salyut-6 and a pneumatic system for transferring it.

. . . In 2 days Progress-1 has "overtaken" the station. Usually the docking is planned for the day after the launch, but this time there are no people on board the craft and there is no reason to hurry. On the contrary, it is even more convenient to prolong the orbit-matching process: It makes the ballistics experts' work easier and less fuel is used on dynamic operations.

When the craft approached the station the automatic rendezvous process began. During this time all space orientation operations are performed with the aid of a radar rendezvous system. It measures the distance between the Salyut-6 and Progress-1 and rate of closing, the station's angular coordinates and the rate of side-slip. The results of the readings undergo logic processing and the computer gives orders to the approaching vernier engine and docking and orientation-system engines. There are about 10 of these engines on the craft and their thrust is considerable but they insure high precision in maneuvering operations. A television camera on the station has been turned on and we can see the blue expanses of Siberia floating past under the craft. (Moscow, Sotsialisticheskaya Industriya (in Russian), Jan. 24, 1978, p. 4.)

Some comments about the space support ship "Volkov" appeared in Izvestiya in late January 1978.

The rookie of the space fleet, the ship "Kosmonavt Vladislav Volkov," is working near the coast of Cuba. This is the flagship of a new series of ships. Their basic purpose, just like that of the ships built in the sixties, the "Kegostrov," "Morzhovets," "Borovichi," and "Nevel," is reception of telemetric and scientific information. But unlike these old ships, the "Kosmonavt Vladislav Volkov," also provides the control center's radio communications with the cosmonauts.

This new ship is smaller than the space fleet's flagship. Displacement of the "Kosmonavt Yuriy Gagarin" is 45,000 tons, but that of the "Kosmonavt Vladislav Volkov" is only 9,000 tons. Nevertheless, the new motorship has rather impressive dimensions: its length is 121.9 meters and beam is 17. Its cruising range is 16.000 miles and speed is 15 knots. The latest compact equipment has been installed on board the "Kosmonavt Vladislav Volkov." It is distributed very efficiently and thus the new ship's opportunities in providing for space flights are very great. (Moscow, Izvestiya (in Russian) Jan. 26, 1978.)

In late January, 1978, Academician Petrov commented on the ramifications of the Salyut 6/Soyuz 27 program.

[Special correspondent A. Pokrovskiy report: "New Paths Are Open: Salyut-6, Soyuz-27, Progress-1: Our Commentary"]

Flight control center—Academician G. I. Petrov comments:

First of all I would like to note that the use of an automatic transport craft to service a manned scientific station is a fundamentally new step in spaceflight. With the docking of Progress-1 the Salyut-6-Soyuz-27 complex significantly extended its potential. Such complexes have the potential to become permanent working bases.

Regular replenishment of essential scientific apparatus and supplies will make it possible to make stations of the Salyut type into scientific laboratories with replaceable teams of specialists. Automatic machines will also help to turn the stations into industrial enterprises—let us say, into chemical plants for obtaining particularly pure materials or technological workshops where, in high vacuum and weightlessness, it is possible to create alloys and structures unobtainable on earth.

We are now calling the automatic transport ship a "truck," but surely it could be assigned the role of a "tug?" With the help of its motors the station could be moved to another orbit, and consequently its potential can be increased.

Since we are talking about the use of automatic machines in near-earth space, I would like to add that they are quite capable of playing an independent role. The most convincing example of this is astronomical platforms precisely oriented toward some heavenly body.

Finally, every new elaboration in space design opens up a concrete path for man's conquest of near-earth space, around the earth, which is inconceivable without assembly work. The more so since during the flight of Salyut-6 Yuriy Romanenko and Georgiy Grechko tested new spacesuits intended precisely for such work. (Academician on Permanence, Potential of Salyut-based Complexes, Moscow, Pravda (in Russian), Jan. 26, 1978, p. 2.)

The following commentaries on the refueling of Salyut 6 appeared in early February, 1978.

After control checks of the airtightness of the fuel lines and containers of the Progress-1 transport ship and the Salyut-6 station, the cosmonauts sent out commands from control panels for the commencement of operations to fill the station's tanks with the oxidizer. The refueling process was controlled by the crew and specialists from mission control centre.

A unique technical experiment involving the refueling of a manned orbital station was carried out for the first time in the practice of space flights. All the instruments and assemblies of the new system of refueling in space performed flawlessly at all the stages of the operation—checking out the airtightness of the refueling lines and the tanks of the transport ship and the space ship, pumping out compressed gas from the fuel tanks of the station by means of compressors, and filling the station's tanks with fuel components.

In the course of the preparatory operations and the refueling, the cosmonauts worked with precision and close interaction with the specialists from mission control centre, ensured the orbital station's refueling within the scheduled time period. (Moscow, Tass (in English), Feb. 3, 1978.)

Moscow, February 3, Tass.—Tass special correspondent Nikolay Zheleznov writes: The last and most labour-consuming discharge operation—to refuel the station and provide it with oxidizer—has been completed at the space port at noon today.

The reserves of fuel and other equipment are quite sufficient for an active continuation of the Salyut-6 flight. Each space launching, however, brings in it, apart from practical goals, new experimental tasks. In this sense the manned expedition of 1977-1978 is a special one. A new station with two docking units was tested at work for the first time. A possibility of the conduct of repair work by the cosmonauts in the open space was tried out. The feasibility and expediency of combining the crews of two delivery spaceships on board an orbital station was proved. (Moscow, Tass (in English), 1333 GMT, Feb. 3, 1978 ["The Way To Prolong Salyut Station's Flight"—Tass headline].)

Commenting on the role of man in space, General Beregovoy stated:

Moscow, February 7, Tass.—"The experiments and tests now carried on in outer space serve to prepare future starts," flyer-cosmonaut Georgiy Beregovoy notes in an interview to the army newspaper Krasnaya Zvezda.

86 human beings have already been on different space orbits. The total duration of the stay of human beings in the extremely specific conditions of space flight equals about four years. Although these figures seem to be rather significant, the process of space exploration is still in the initial stage, Beregovoy said. Long-term orbital stations, increasing duration of flights, crammed working programmes, do not rule out, in my opinion, one feature of the professional duties of cosmonauts: They are not only explorers and experimenters, but also testers. (Moscow, Tass (in English), 1050 GMT, Feb. 7, 1978.)

Multimodal space stations of the future and the capabilities of resupply spacecraft were discussed in the following articles.

"Progress" has become a space tug. In the future, probably, special space tugs will operate in circumterrestrial space and these will be able to transport freight from low orbits into higher orbits, for example, for the construction of multiton "islands." The latter may be in a geosynchronous orbit at a distance of about 36,000 km from the earth. (Moscow, Izvestiya (in Russian), Feb. 7, 1978, by B. Konovalov.)

Moscow, February 8, Tass.—The Soviet spaceship Progress-1, which has a mass of 7,020 kilograms, can bring into an orbit around the earth 2,300 kilograms of equipment, materials, fuel and gas. This ratio is high enough for contemporary space technology, Pravda writes today. (Moscow, Tass (in English), 0940 GMT, Feb. 8, 1978.)

[Article by Candidate of Technical Sciences Yu. Pavlov and Engineer L. Ivanov Article: "Tanker, Frieght Carrier and Tug"]

The ever-increasing duration of flights by cosmonauts has put forward an imperative demand that ways be found to replenish materials expended in orbit and equipment that has exhausted its useful life. The level of modern technology still does not make it possible to set up production of the necessary resources directly in space. Therefore the most effective way at present to replenish stocks on scientific stations designed to operate for long periods is to develop freight transport operations which link the earth with the station's orbit. The Progress-1 freight transport spacecraft was created in the Soviet Union for this purpose.

The docking unit of the Progress contains additional automatic hydraulic connectors in comparison with the analogous unit on board the Soyuz. These insure the hermetic coupling of the main hydraulic conduits of the freighter's refuelling system with the main hydraulic conduits of the station's motor installation when the latter is being refuelled. The hatch of the docking unit can be opened both automatically and also manually by the crew.

The bulk of the units of the refuelling system and gas replenishment system are housed in the second compartment; these consist of four fuel tanks, spherical containers filled with compressed air and nitrogen, pneumatic and hydraulic units, sensors, indicating devices and other elements. The total quantity of fuel and gases which can be delivered is 1,000 kilograms.

The refuelling and air replenishment system are fundamentally novel on the Progress, since these operations were unprecedented in space flights. They operate automatically on commands from the ground or from Salyut. (Moscow, Pravda (in Russian), Feb. 8, 1978, p. 3.)

The use of satellites for the experimental transmission of newspaper photocopies was the subject of a February, 1978 Pravda article.

"A year ago Pravda reported the start of the experimental transmission of photocopies of central newspapers from the capital to Khabarovsk via satellites of the Orbita communications system," S. I. Martsenitsen continues. "And now the tests of the Moscow-space-Far East line have been completed. This line has been commissioned. Some 11 publications are now sent to Khabarovsk via space communications channels. Preparations have begun for the regular transmission of newspapers via artificial earth satellites to other remote cities of the country too. In the long term it is planned to create such lines between Moscow and Irkutsk, Magadan, Vladivostok and Yuzhno-Sakhalinsk."

The building of new reception centers for newspaper pages is continuing. This year transmission lines to Mineralnyye Vody, Ufa, Frunze, Voroshilovgrad, Kishinev, Tbilisi and Baku will be commissioned. It is thought that the day is not far off when it will become commonplace for all the inhabitants of our vast country to receive central newspapers at the same time as Muscovites do. (Moscow, Pravda (in Russian), Feb. 13, 1978.)

Some metallurgical experiments conducted on board the Salyut 6/Soyuz 27 complex were reviewed.

Moscow, February 15, Tass.—A Tass correspondent reports from mission control centre: The crew of the Soviet orbital research complex Salyut-6-Soyuz-27 has started the fulfilment of planned technological experiments. Today Yuriy Romanenko and Georgiy Grechko carried out the first such experiment by means of the installation "Splav" (alloy). To lessen the influence of dynamic perturbances on the course of the experiment, the orbital complex was put in the drift regime under which all engines of the orientation system are switched off.

The cosmonauts placed a capsule containing materials under study into an electric heating chamber installed in a special airlock. After the airlock was depressurised the system of electric heating was switched on. The necessary temperature regime was maintained in the working zone throughout the required period. The process of crystallisation of molten substances followed the programme of regulated cooling. All operations to ensure optimal temperature regimes were performed by means of a programming unit. (Moscow, Tass (in English), 1234 GMT, Feb. 15, 1978.)

"There are three heat zones in the Splav-01," we were told by one of its designers, A. V. Yegorov. "A constant temperature is maintained in the two outer zones—higher in one and lower in the other—while in the central part we can provide a gradual temperature drop lengthwise through the zone. The two outer zones can be utilized for so-called volume crystallization of various alloys, when the mixture is heating, melting and subsequently cooling. The process of controlled crystallization can be performed in the central zone."

As the unit is in operation, the solution cools, and the crystallization zone creeps slowly to the right, as it were. A single crystal grows on a primordial tiny seed and reaches a size suitable for practical utilization, in the electronics industry, for example. (Moscow, Izvestiya (in Russian), Feb. 16, 1978.)

Earth-Mars-Jupiter windows for the 1979-90 period were analyzed in early 1978.

A study was made of Earth-Mars-Jupiter flight trajectories. The authors give a method for computing the trajectories which are optimum with respect to power requirements and their numerical characteristics for the years 1979-1990. Also considered are the conditions for a flight around Mars, the influence of a "window" of launchings on the trajectory characteristics and the effectiveness of the correcting maneuvers in different flight segments. It is shown that in individual launching years trajectories with gravitational flight around Mars ensure a substantial energy advantage. (Flight Trajectories to Jupiter, Moscow, Kosmicheskiye Issledovaniya (in Russian), vol. 16, No. 1, 1978, pp. 38-42 [Article by K. G. Georgiyev and O. V. Papkov, "Flight Trajectories to Jupiter Using the Martian Gravitational Field"].)

Studies of the Earth's atmosphere and its meaning for the future were also the subject of Salyut 6 experimentation.

Out of the thousand circuits made by the Cosmonauts Yuriy Romanenko and Georgiy Grechko on board the Salyut-6 station 150 were registered in their logbooks as devoted to active observations of the earth's atmosphere, in particular, of silver clouds. This development enables scientists to consider the Salyut-6 expedition as the biggest ever geophysical experiment in space orbit.

The importance of this effort is obvious. The amount of aerosoles and carbon dioxide at various altitudes is growing. Scientists believe that by the year 2000 the discharge of carbon dioxide into the atmosphere will increase 50 per cent as compared with the present time. And this, of course, will introduce substantial changes into the planet's heat balance. (Moscow, Feb. 15. 1978, Tass.)

Experiments dealing with metallurgical processes in space continue to receive attention in the Soviet space program, and in particular, continue on Salyut 6.

Yesterday on board the "Salyut-6-Soyuz-27" complex the second technological experiment on the "SPLAV" system began. The following pairs were chosen as substances to be studied: aluminum—tungsten, molybdenum—gallium, as well as semiconductive material. Earlier on the "SPLAV" system experiments were carried out using the following compounds: copper—indium, aluminum—magnesium, and indium antimonide. (Moscow, Pravda (in Russian), Feb. 18, 1978, p. 1.)

Yesterday the second experiment on the "SPLAV" installation was completed. Under weightlessness conditions compounds of the following pairs of substances were obtained: aluminum and tungsten, gallium and molybdenum, and also a semiconductor material. Sealed containers of the materials obtained will be returned to earth for study of features of the interaction of solid and liquid metals under weightlessness conditions. This is important for understanding processes of welding and soldering and the creation of new composite materials havings practical significance. (Moscow, Pravda (in Russian), Feb. 20, 1978.)

The joint Soviet/French biological experiment on Salyut 6 was described in the following Tass article:

Moscow, February 20, Tass.—The Soviet-French complex of thermostatic equipment has successfully passed the test in terrestrial and space conditions, the newspaper Izvestiya writes today. These instruments are simple and reliable.

Biological cultures prepared by Soviet and French biologists were "put asleep" in an ordinary refrigerator and placed within a special insert into the Soviet semiconductor instrument "Termokont-2."

On the eve of the launching of the spaceship "Soyuz-27," "Termokont-2" handed over its biological "load" to another Soviet instrument, the thermostat "Bioterm-8." Its task was to maintain the same temperature of plus eight degrees centigrade during the launching of "Soyuz-27" and its stay in orbit right til docking with the orbital station "Salyut-6."

"Bioterm-8" operated impeccably during this period and after docking the biological insert was placed into the French semiconductor thermostat "Cytos." There the cultures of cells were "awakened" by warmth and the experiment to study the influence of space flight factors on the cellular division of micro-organisms was started at the strictly contolled temperature of plus 25 degrees centigrade. (Moscow, Tass (in English), 2024 GMT, Feb. 20, 1978.)

A cryogenic system for a space telescope on Salyut 6 received the following comments:

CRYOGENIC SYSTEM FOR SUBMILLIMETER TELESCOPE TESTED

A closed-cycle cryogenic system designed to obtain the temperature of liquid helium (−269 degrees C) was tested on 21 February. This temperature is obtained through the operation of a compressor, two gas refrigeration machines and intermediate heat exchangers and by cooling gas at the decisive stage as it flows through an expanding nozzle. The purpose of the cryogenic system is to cool the radiation detector of the submillimeter telescope BST-1M mounted on "Salyut-6" station. Tests showed that the system functions well.

During technical experiments on 21 February, the cosmonauts put the submillimeter telescope into operation (Pravda, Feb. 22, 1978, p. 2). They adjusted the telescope and its optical viewer relative to the station's astroorientation system through observations of Sirius and Jupiter. They also tested the telescope's own autonomous control system.

Measurements were made of submillimeter radiation of the earth's atmosphere by directing the axis of the telescope toward the earth. Information on atmospheric radiation in the submillimeter range makes it possible to establish the existence and movement of active regions of increased moisture content (Pravda, Feb. 23, 1978, p. 4.)

FLIGHT CONTROL CENTRE, February 23, Tass.—"We have liquid helium"—this report, an unusual one for a space radioline, came on the 73rd day of the space mission aboard the manned orbital station Salyut-6. It meant that Yuriy Romanenko and Georgiy Grechko started a new series of experiments in outer space. It began with the testing of a cryogenic system, a unique device designed for cooling miniature crystals which act as receivers of radiation in the onboard telescope. Instruments at the telescope control panel showed a record temperature of minus 269 degrees for this type of instruments, only 4.2 degrees above absolute zero. (Moscow, Tass (in English), 1930 GMT, Feb. 23, 1978.)

The Soviets continued to maintain a high level of interest in the concept of closed-circuit, biological life support systems utilizing the single-cell alga Chlorella. Experiments on this concept continue in Salyut 6.

Experiments aboard the space complex have already begun. The first of these is biological. It is being carried out with the well-known green alga Chlorella. This lower plant has already been in space more than once. The interest of scientists is understandable: Chlorella will be specially created for the greenhouses of future interplanetary ships and long-lived stations with a closed ecological system. Reference is to an autonomous biosphere in which the plants absorb carbon dioxide from the air and enrich it with oxygen and give man water, some food, everything necessary for life. Now space stations and ships have special absorbents and regenerators for maintaining the normal composition of the air, apparatus taking water from the air in the ship, and containers with food. It is impossible to store all this for a year or two for distant voyages into space. This means that it is necessary to create a closed biosphere with the complete cycling of matter in a relatively small volume of spaceships or stations. This problem is exceedingly complex. Chlorella is also interesting in that it very actively absorbs carbon dioxide and releases oxygen, simultaneously yielding water and food. It is rich in proteins and in chemical composition in a quite adequate nutritious product. Still another merit of this surprising alga is that it matures rapidly, which is very important for the space greenhouse.

Earlier space experiments with Chlorella gave scientists rich material. But, to be sure, by no means all problems have been solved. A further development of these investigations is the experiment carried out by the international crew aboard the "Salyut-6"-"Soyuz-27"-"Soyuz-28" complex. This time it is not Chlorella alone which is in use; other algae are also being employed. And the Chlorella itself is unusual: in addition to the normal algae there are special modified forms, so-called mutants, which have no chlorophyll.

Aleksey Gubarev and Vladimir Remek delivered to the "Soyuz-28" four small containers with a nutrient medium and nine sealed ampules which contain algae. By means of special devices the cosmonauts broke some of the ampules and the algae can now develop rapidly. Other containers are control ampules. After return of the containers to earth the scientists will compare the algae. This will make it possible to learn how weightlessness acts on the cells of lower plants which are at rest and which are actively growing.

Three different types of algae are developing in one of the containers. Will there be a "competition" among them which will lead to a "struggle"? This is a question which is of interest to specialists. Similar investigations are being carried out simultaneously on earth.

Unicellular algae have become part of the first experimental systems for regeneration of the atmosphere and water, successfully operating in terrestrial laboratories. New investigations aboard the space complex will make it possible to take still another step on the path of development of promising ecological systems.

Preparations for the "Chlorella" experiment were carried out jointly by the scientists of the Soviet Union and Czechoslovakia. A careful selection was made of the species and forms of algae and a method was developed for carrying out the experiment. The materials returned from space are sent for investigations to the laboratories and institutes of the USSR and CzSSR. (Moscow, Trud (in Russian), Mar. 8, 1978, p. 3 [Article by V. Golobachev: "Four in the Stellar House"].)

K. Feoktistov discussed the possible uses of space for economic profit in this March 16, 1978 interview.

For the time being there is no unanimous opinion: will cosmonautics follow the path of manned flights or will preference be given to automated mechanisms? Most leading problems, such as astrophysical investigations and the monitoring of natural resources, etc., can be solved by means of automatic vehicles. The prospects for manned orbital stations, possibly, are related to industrial construction in orbit.

But this is my subjective point of view, which many, probably, will not share. However, I feel that in the coming decades the developing technology will make it possible to solve the problem of creating in terrestrial orbit systems of energy satellites with an area of about tens of square kilometers. Such giants will transform solar energy into electric power and by means of radio waves will transmit to the earth a power of tens of millions of kilowatts.

The creation of such giants will require the implementation of industrial construction in space. This means that millions of tons of equipment and materials must be put into orbit where it will be necessary to construct factories for the transformation of these materials into construction parts which will be assembled into giant constructions. However, such production will scarcely be completely automated. Without question, automatic equipment will be used there, but the assembly and control of the entire process will probably remain to people and large teams of men will undoubtedly participate in the creation of such giant structures.

The roads to this end are still distant and long. But the experience of man's prolonged presence in space, the development of means and methods for the approach and docking of ships, the possibility of putting freight into orbit, this is the very experience which we can then use for industrial activity in orbit. I think that such activity is ahead of us.

To be sure, there can also be another direction in industrial activity in space. For example, it may prove to be desirable to construct factories in orbit for the production of materials under weightlessness conditions. These can be ultrapure metals, semiconductors, ultranew biologically active substances, drugs, etc.

However, if one speaks of the main lines in development of cosmonautics in general, then in my opinion the principal condition for most projects must be profitability.

Without question, curiosity has been a considerable stimulus in our activity. And it will probably also motivate us in the future. But in the immediate neighborhood of the earth there is scarcely anything that interesting. But if we succeeded in finding life on Mars and learned to understand its genetic code, this would be extraordinary and extremely interesting, but there are scarcely great hopes for this.

But there is hope for economically profitable activity of the type I mentioned. And possibly this will become the principal condition for the development of space technology. It is another thing that such a direction is not being formulated at once, but I emphasize that these are my subjective points of view.

In addition to the use of circumterrestrial space and planetary cosmonautics it is necessary, to be sure, to define still another direction—fundamental investigations, in particular, the creation of powerful tools for astrophysical research, operating in different spectral ranges. (Moscow, Komsomol'skaya Pravda (in Russian), Mar. 16, 1978, p. 2 [V. Zubkov interview with K. Feoktistov: "An Orbit of Optimism"].)

In March 1978, Tass announced that Soviet scientific progress would enable man to live in space for over a year. A March 1978 "Trud" article explained the importance of long manned space flight for future planetary exploration.

Moscow, March 17, Tass.—"Man can live and work in outer space for over a year." This conclusion was made by Soviet scientists after summing up the preliminary results of the 96-day orbital flight made by flier Yuriy Romanenko and Flight Engineer Georgiy Grechko. Professor Anatoliy Yegorov who heads the medical group of the Flight Control Centre, singled out four factors that warranted such an optimistic conclusion. "Throughout the flight," he said to Tass, "the cosmonauts retained high creative interest in scientific research and experimental work. They carried out over 50 major planned investigations and approximately as many at their own initiative."

"The cosmonauts displayed an amazing spirit of creativity and capacity for work," he said.

As a second factor Professor Yegorov mentioned correct forecasting by specialist of the effects of weightlessness on the human body, and means of neutralizing them. A large dose of physical exercises and loads the crew got on the running track, veloergometer as well as the use of the load suit Penguin and the suit Chibis which coordinate blood flow in the body to bring it closer to that one has on earth—are some of the measures which predetermined the good condition of Yuriy Romanenko and Georgiy Grechko. (Moscow, Tass (in English), 1321 GMT, Mar. 17, 1978.)

A study of body adaptation to weightlessness is very important for specialists. For example, a flight to Mars can have a minimum duration of three years. In case of necessity the ship would not return to the earth and would not land at any time. It is necessary to know precisely whether the human body could contend with such a flight, what preventive measures would be required and whether it is necessary to develop an appropriate biomedical strategy . . . All this must be known in order to ensure effective operation of long-term orbital stations in circumterrestrial space. (Moscow, Trud (in Russian), Mar. 17, 1978, by V. Golobachev.)

In March and April 1978, Tass announced that the U.S.S.R. would launch scientific satellites for magnetospheric research and satellites for improved weather reporting and ship navigation.

Moscow, March 30, Tass.—A variety of spacecraft are to be launched before the end of 1979 under the international magnetospheric research programme. Among them will be the Soviet Ionozond satellites, satellites of Prognoz series and the American Geos-2, Vladimir Migulin, a noted Soviet expert in this field, told a Tass correspondent. The director of the Institute of Terrestrial Magnetism, Ionosphere and Propagation of Radio Waves, gave an interview in connection with the completion of the work in Moscow of the committee which is in charge of the international magnetospheric research programme. The complex of satellites—Soviet, Intercosmos series, European and American ones—as well as air balloons will help explore a vast area of the near-earth space at different altitudes, Migulin said. Ultimately man must learn [to] forecast solar flashes, magnetic storms, northern lights, and radiation hazard for space flights, and make long-term forecasts as to propagation of radio waves.

Moscow.—On 31 March the Cosmos-1,000 artificial earth satellite was launched in the Soviet Union.

The satellite is designed to perfect the space navigation system that is being created to insure the determination of the location of U.S.S.R. ships from the merchant marine and the fishing fleet in any spot in the world's oceans. (Moscow, Tass International Service (in Russian), 1219 GMT, Apr. 1, 1978.)

Space radio beacons open new horizons, offering an opportunity for establishing a global all-weather and highly accurate system for navigation. The satellite keeps sending to earth signals of a definite frequency. These are received by ship aerials and enter an electronic computer for processing.

The basic principle in determining coordinates by signals from the satellite is the use of Doppler effect. The frequency of the signals changes because of the great speed of the satellite. Using these data the electronic navigator produces navigational information in a convenient form—geographical coordinates and precise astronomical time. This makes it possible to automate ship navigation to the utmost.

Together with Molniya and Meteor satellites, which ensure trouble-free communications through outer space and efficient transmission of weather reports, navigation satellites will help enhance considerably the effectiveness of the use of the sea fleet and ensure the safety of sea navigation in all parts of the world ocean. Geodesists and geologists, for whom astronomically accurate coordinates are also of great importance, have long been dreaming of such apparatuses. (Moscow, Tass (in English), Apr. 1, 1978.)

Two articles published in April 1978 describe the possible use of satellites in the production of electricity and solar energy.

Let's consider electric stations in orbit. Westerners have begun to talk about them in connection with the energy crisis in the capitalist world. There are already many plans for them in existence. But, indeed, they will turn out to be unnecessary if scientists can ignite a controlled thermonuclear reaction on earth.

Therefore, long-range predictions are risky. Only one thing can be said here for certain: the use of rocket and space technology in scientific research has already resulted in many remarkable discoveries that have changed our previous conceptions of space, earth and their interrelationships. (Interview with V. A. Shatalov: "Path to the Stars") Moscow, Sovetskaya Rossiya (in Russian), Apr. 10, 1978, p. 4.)

High-capacity heliostations can be constructed in space, giving us on earth the possibility of using part of the great energy of the sun. Plans for them already exist. Space will become the industrial foundation of future humanity. Under the specific conditions of space and celestial bodies, many technological processes can be organized highly effectively. Mankind will remove from earth those energy installations that discharge heat that is harmful to the environment. (Moscow, Trud (in Russian), Apr. 11, 1978, p. 4. [I. Yudin interview with G. T. Beregovoy: "Beyond the Limits of the Earth"].)

Academician B. Petrov discussed the important role of Salyut 6 in the development of Soviet cosmonautics in this April 11, 1978 Tass announcement.

Contemporary science and development of national economy, said Academician B. Petrov, chairman of the Intercosmos Council of the Academy of Sciences of the USSR, call for an increasingly wider use of outer space equipment. "Soviet science regards the creation of orbital stations with replaceable crews as man's main road to outer space," as was pointed out by general secretary of the CPSU CC, President of the Presidium of the USSR Supreme Soviet Comrade Leonid Ilyich Brezhnev. The development and successful functioning in orbit of the new scientific orbital complex on the basis of Salyut-6 is the best illustration of the fact that Soviet cosmonautics is confidently advancing along this road. The creation of the complex has opened a new chapter in space exploration, a new stage in the development of world cosmonautics. The Salyut-6 station is a space craft of the next generation compared with the preceding orbital stations. It has two docking units and makes it possible to receive two spaceships simultaneously. (Moscow, Tass (in English), Apr. 11, 1978.)

Several Tass announcements in April 1978 described the participation of cosmonauts from Eastern Europe, Mongolia, and Cuba in the Salyut 6 program.

Citizens of Poland and the GDR, who underwent training in the Star City, are to take part in the next expeditions, Petrov said. The time of their flights will be determined after a careful processing of the results of the present expedition. The flights have been scheduled for 1978. The question of longer Soviet expeditions will be decided only after a careful study of the results of this flight of record duration. Joint crews of cosmonauts of the USSR, Poland and the GDR will work on board the Salyut-6 station. The transport space craft Progress will also be used for the supply of new expeditions. (Moscow, Tass (in English), 1845 GMT, Apr. 11, 1978.)

USSR decorations have been awarded to the heroes of the space epic. Leonid Ilich Brezhnev, general secretary of the CPSU Central Committee and chairman of the USSR Supreme Soviet Presidium, presented high awards of the Soviet Union to the participants in the 96-day heroic space epic in the Kremlin today. Orders of Lenin and Hero of the Soviet Union Gold Star medals were awarded to the USSR pilot-cosmonauts of the orbital scientific research complex Salyut-6-Soyuz—Romanenko, Grechko, Dzhanibekov, Makarov, and Gubarev—and Czech cosmonaut-researcher Remek.

For the successful accomplishment of the lengthy flight on board the orbital Salyut-6-Soyuz complex and for the fortitude and heroism they displayed, our long-livers in space have been honored with high awards: Comrade Yuriy Viktoravich Romanenko has been awarded the title Hero of the Soviet Union; and USSR Pilot-Cosmonaut Georgiy Mikhaylovich Grechko has been presented with the Order of Lenin and a second Gold Star medal.

For the excellent fulfillment of the flight on the Salyut-6-Soyuz complex and the implementation of an extensive program of experiments, Comrade Vladimir Aleksandrovich Dzhanibekov has been awarded the title Hero of the Soviet Union, and USSR Pilot-Cosmonaut Oleg Grigoryevich Makarov has been presented with the Order of Lenin and a second Gold Star medal.

The feat of the members of the international space crew has won high appraisal. For successfully carrying out the spaceflight on the orbital scientific research complex Salyut-6-Soyuz, Comrade Aleksey Aleksandrovich Gubarev has been awarded the Order of Lenin and a second Gold Star medal; and Comrade Vladimir Remek has been awarded the title Hero of the Soviet Union. (Moscow, Domestic Service (in Russian), 1000 GMT, Apr. 11, 1978.)

Moscow, April 12, Tass.—"A qualitatively new stage in the development of the Intercosmos programme is connected with the beginning of international space flights. Future cosmonauts, citizens of Poland and the GDR, are completing their training now and citizens of Bulgaria, Hungary, Cuba, Mongolia and Romania started training," said Academician Boris Petrov, the chairman of the Intercosmos Council. (Moscow, Tass (in English), 1608 GMT, Apr. 12, 1978.)

This April 1978 Hungarian newspaper article described some benefits of the Soviet space program.

The man-made satellites have also been used in so-called radio navigation, servicing to precisely determine the location of ships. Thanks to the man-made satellites watching the movement of these and of the icebergs, no major ship catastrophes or collisions have taken place on the open seas for years. The experts call attention to the fact that the last such major accident occurred on the edge of the Northern Arctic Ocean during the initial stages of space research. But today the airplanes are also enjoying the advantages of navigation by man-made satellites.

Space production of technical nature can be expected soon, for example in the production of tungsten of very high quality. This also affects and may interest Hungary, since we are a country producing incandescent lamps in large quantities. As shown also by the Salyut-6-Soyuz-28 experiments, the experiments are also conducted within the framework of Interkosmos, the socialist countries' joint space research program.

It is interesting that turbine blades are expected to become one of the first products produced industrially on spaceships. That is, if the internal structure of the blade's metal is right in the longitudinal direction, then the blade is firmer, it wears less, and consequently blades of smaller weight can be used. This makes possible significant savings of metal. The life span of such blades is much longer. Today, manufacturing is in the preparation stage.

But perhaps the manufacture of pharmaceuticals is the most important for humanity among the tasks which can be solved within the framework of production in space. On spaceships, because of the use of weightlessness, biologically effective agents have been successfully separated. Progressing along this path, a hormone of the lining of secondary kidney has been produced on a space station, which promotes the proliferation of red blood cells. This product may have tremendous significance before kidney transplant operations, because through its use regular blood transfusions will not be necessary. (Budapest, Nepszabadsag (in Hungarian), Apr. 12, 13, 1978 [Parts 2 and 3 of article by Gabor Pal Peto: "Man and the Universe"].)

Feoktistov, Cosmonaut and Doctor of Technical Sciences, was interviewed for this April 12, 1978 article on the future of orbital space stations.

[Correspondent G. Lomanov interview with Konstantin Petrovich Feoktistov, pilot-cosmonaut of the USSR, doctor of technical sciences and Hero of the Soviet Union: "Road to the Stars"]

Question. How do you picture the future of orbital stations?

Answer. They will develop above all as multipurpose scientific laboratories. Medical and biological experiments making it possible to ascertain how long man can live and work in space without harming his health will continue on board the stations. As before, great significance will also attach to manned stations for the study of natural resources—the highly effective nature of this work has already been proven by practice. It is no accident that in the past 2 years the number of organizations using space information in the interests of the national economy has doubled.

The orbital stations' unique potential will also be used for extra-atmospheric astronomical observations and for technological experiments making it possible to obtain materials that under earth conditions cannot be obtained at all or cost too much. In a word, in fulfilling national economic tasks, the orbital stations will also serve to seek out the most effective systems of methods for developing methods for research and the design of scientific instruments and equipment.

The problem of the optimal distribution of duties between man and machine is becoming increasingly topical with the increase in the duration of space flights. There is much that is controversial here: Some specialists believe that space is above all a sphere for the operation of machines. There is reason in their arguments: For instance, astrophysical observations even in the immediate future could be carried out with the aid of preprogrammed apparatus. Research into natural resources is also perfectly within the powers of modern radio- or program-controlled television equipment. But it is still people who have to elaborate the methods for this research and correlate the degree to which the information obtained by machine corresponds with the real picture.

In my view, very broad prospects are opened up for manned stations if they are examined above all as the basis for industrial construction in space. Not everyone shares this view, but I personally believe that within the next few decades the development of technology will make it possible to actually set the task of creating powerplants in space. These installations, gigantic by present standards and covering tens of square kilometers, will trap solar energy and convey it in transformed form for use on earth. With time, technological experiments will lead to the creation of real industrial enterprises in orbit.

And this means that millions of tons of diverse equipment will have to be put into space and enormous and complex structures will have to be assembled there. Such work can scarcely be fully automated. People—large collectives of people, moreover—will control the equipment and carry out installation work. Of course, this will not happen rapidly and many people may relegate such forecasts to the realm of fantasy. But after all, 17 years ago Yuriy Gagarin's flight also seemed a fantastic achievement. (Moscow, Sotsialisticheskaya Industriya (in Russian), Apr. 12, 1978, p. 3.)

On May 2, 1978, Academician Sagdeyev predicted that space stations would soon be used for industrial production.

Moscow, 2 May, Tass.—Very soon, perhaps in the next few decades, research and industrial complexes will be built in terrestrial orbit. Metallurgical, engineering and chemical plants will be built there. Industries will appear in outer space which cannot be organized on earth in any case, according to Academician Roald Sagdeyev, Director of the Space Research Institute U.S.S.R. Academy of Sciences. (Sagdeyev Views Prospects for Soviet Cosmonautics, Moscow, Tass (in English), 2057 GMT, May 2, 1978.)

The Soviet military newspaper "Krasnaya Zvezda" on July 4, 1978 described medical research being conducted to prolong manned flights.

In speaking of original medical and psychological experiments, Academician J. Rychlewski had in mind such Soviet-Polish experiments as the "Kardiolider," "Dosug" and "Opros." What is the essence of the mentioned experiments?

The "Kardiolider" experiment consists of two parts. In the first case the "Kavkazy" successively donned the "Chibis" suit, by means of which a rare-faction is created for the lower half of the body. As is well known, such a simulation results in the outflow of blood from the head to the legs. In the second case, use is made of the on-board bicycle-type ergometer. In both cases the specialists check the state of the cardiovascular system. This was done using the "Kardiolider-DOI" instrument. The latter was fabricated by the x-ray apparatus and medical devices plant in Warsaw. The action of the instrument is based on an analysis of the dynamics of cardiac contractions by means of measuring the bioelectric currents of the heart. The instrument weighs only 200 grams, has an autonomous current source and makes it possible to check the changes in the frequency of cardiac contractions in a wide range—from 60 to 180 beats per minute. Using a bicycle-type ergometer the "Kavkazy" have carried out two loads of a conditioning nature: limbering up (to a pulse rate of 130 beats per minute) and increasing (up to 150). When the frequency of cardiac contractions exceeded these stipulated levels, the instrument triggered a signal and the cosmonauts in the first case reduced the intensity of turning of the pedals, and in the second case stopped it altogether.

Scientists feel that the results of such investigations will make it possible to develop an effective system for preventing disorders of the cardiovascular system during prolonged space flights and maintenance of high performance of cosmonauts during all flight stages.

All these experiments have great importance even today when expeditions aboard orbital stations are becoming increasingly saturated and prolonged. But they are still more important for the tomorrow of cosmonautics. Indeed, the time is probably coming when the work of the crews aboard stations will continue for long months, and possibly years. The time is coming when earthlings will travel on interplanetary ships into the distant expanses of space in order, upon their return, to bring to man the knowledge which they have won from the universe. (Moscow, Krasnaya Zvezda (in Russian), July 4, 1978, by V. Ovcharov.)

A July 5, 1978 "Trud" article discussed future construction of industrial plants in space. This topic was also discussed in a July 6, 1978 "Pravda" article.

He was referring to the continuation of technological experiments in the "Splav-01" automatic electric heating installation that is on the orbital station. Into the heating chamber the cosmonauts placed small cylindrical ampules with a solid solution of cadmium telluride and mercury telluride. These very different materials are heated to a very high temperature, melted, and then, scientists expect, they will crystallize as they cool, forming a homogeneous semiconductor. This semiconductor could be used in supersensitive medical and electronic instruments. The experiment was prepared jointly by Soviet and Polish specialists (an ampule was sent from the Polish Academy of Sciences Institute of Physics). The smelting of cadmium, mercury and tellurium was conducted earlier on the station within the framework of the Soviet national program. It will be interesting to compare the analysis data of these alloys as obtained by Polish and Soviet specialists.

Commenting on these studies, Candidate of Technical Sciences, USSR Pilot-Cosmonaut V. N. Kubasov, who participated in two space flights, noted:

"Due to technological experiments on the station, we are nearing the time when unique industrial plants making use of the vast space vacuum and weightlessness will be constructed in near-earth space. Such plants must necessarily be created and perhaps even sooner than supposed by science fiction writers. However, it is first necessary to conduct intensive research and to determine just which materials can be obtained in space and just how they are to be produced. When these studies are completed, the question of constructing workshops and entire industrial plants in orbit will arise. Perhaps it will be possible even for me to work in such a plant. . ."

We discussed this with the designer of space systems, Doctor of Technical Sciences Professor K. P. Feoktistov.

"I think that the development of space technology will be closely linked with industrial activity in near-earth space," said the scientist. "This, apparently, will include not only workshops and plants in orbit, but high-capacity power stations as well. In fact, it is tempting to use solar energy to manufacture electricity, without polluting the earth and spoiling its natural resources. According to my estimates, the cost of such energy could be equivalent to that of what is presently being produced in earth-based power stations. Of course, these will have to be enormous structures. Let's say, an orbital power station with a 10-million kilowatt capacity will have to have solar cells with an area of 50–70 square kilometers. The antenna to transmit the energy to earth will be 1–1.5 kilometers in diameter. And the receiver on earth would cover an area of several square kilometers. Hundreds of these power stations would be required to accommodate all of mankind. And to construct them, factories in orbit to build the structural components are needed. . . Orbital stations are the experimental test area and the building ground for future industrial endeavors. . ."

"In what direction are the Soviet orbital stations developing?"

"Our first 'Salyut'," emphasized K. P. Feoktistov, "was, generally speaking, a 'test of the pen.' Many technical aspects of the 'Soyuz' transport ships, some of the equipment and components of the 'Soyuz' energy supply and orientation systems were adopted. The station was inserted into orbit on 19 April 1971 and proved to be highly useful. The service life of subsequent 'Salyut' ships was increased, and the energy indicators and fuel reserves were improved. New scientific equipment and airlocks for waste and refuse disposal appeared on 'Salyut-4,' and the station was made more comfortable. But already as soon as 'Salyut-4' was launched, it was obvious that a second docking unit was needed. It is a pity to stop work on a station because its fuel reserves have been depleted. The second docking unit makes it possible to refuel the station and markedly widens its capabilities."

"I imagine that in the future there will be space stations with several docking units. Modules will be docked to allow specialized research, for example, in geophysics, astrophysics and technology, to be conducted. . ."

"Throughout the time of construction and operation of a station, the scientific equipment, of course, becomes outmoded. New modules can be outfitted with more highly developed technology. I think that priority development in the near future will be in the modular construction of orbital stations." (Moscow, Trud (in Russian), July 5, 1978, p. 4 [Article by V. Golovachev: "The Future of the 'Salyut' "].)

"The advantages of orbital complexes is obvious," adds USSR Pilot-Cosmonaut Professor K. P. Feoktistov. "They can act as a prototype for future industrial enterprises in space by demonstrating the usefulness of the principle of modular construction. It is possible to imagine that, similar to the way in which manned transport and automatic freight ships are now docked to a space station, interchangeable modules with improved or new equipment will be moored with a basic space enterprise unit or an orbital laboratory according to rising demands." (Moscow, Pravda (in Russian), July 6, 1978, p. 6 [Article by A. Pokrovskiy: "Separating and Meeting"].)

On July 16, 1978, "Izvestiya" carried a discussion of the possible benefits of glass production in space. "Pravda" also carried discussions of future production of glass crystals and film structures in the weightless conditions of outer space.

At the Flight Control Center one of the formulators of the experiment, Corresponding Member USSR Academy of Sciences G. Petrovskiy, told newspapermen about what horizons are opening up before science and technology from this first test in orbit.

"In his time Sergey Ivanovich Vavilov noted that glass is the main component of optical systems," says G. Petrovskiy. "This assertion is also correct in our day, despite the broad penetration of electronics into optical instruments. The mastery of space is opening new horizons before optics and is affording a possibility for using new technological procedures for the creation of valuable materials and improving the properties of glass. Optics was one of the scientific and technical directions which made the storming of space possible. From the first flight, when Yuriy Gagarin saw the earth through his window, it [glass] has been soundly serving cosmonauts. And now cosmonauts in turn can assist in the development of optical instrument making."

By means of certain additives it is possible to impart to the glass valuable properties which are widely used in modern technology. For example, the addition of niodymium ions makes it possible to obtain glass capable of generating laser radiation. "Admixtures" of terbium and cerium create magnetically active materials used as optical shutters which can transmit radiation in only one direction. Photochromic glass enjoys a great popularity; it becomes darker in the sun and becomes clearer in darkened rooms.

The more uniform the distribution of the additive, the better is the quality of such alloyed glass. But a uniform distribution is difficult to achieve under terrestrial conditions. On photographs taken using electron telescopes it can be seen that the ions of heavy "impurities" have a tendency to collect into groups, resembling swarms of bees. Scientists hope that under weightlessness conditions this interaction among ions of impurities will be weakened and the distribution of additives will be more uniform. In one of the ampules in which the melting and cooling of glass took place under weightlessness conditions specialists placed "additives" of iron in order to check this hypothesis.

Modern technology requires purer and purer glass. But no matter how much the purity of the initial materials is increased, there is a problem with the walls of the vessels in which the glass mass is melted. At a temperature of 1,400° there are very few materials which can retain their strength and the glass is inevitably contaminated. Even costly platinum vessels are no solution to the problem. Platinum also partially passes into the hot melt and with subsequent cooling is released, segregated, in the form of tiny crystals which considerably reduce the optical properties of the materials.

Space can also be of assistance here. Under weightlessness conditions it is possible to carry out crucibleless melting of glass, holding it by means of a system of acoustic sources creating a definite pressure. in principle, on earth if one makes use of very powerful acoustic generators it is also possible to "suspend" tiny masses, but after all, for industrial purposes it is necessary to have quite large particles. By such a method it is possible to obtain very pure glass or new types of glass with different additives which it is difficult to obtain under terrestrial conditions because very high temperatures are required and there are no vessels capable of withstanding them. (Moscow, Izvestiya (in Russian), July 16, 1978, p. 4 [Article by B. Konovalov: "Glassmakers in Space"].)

On earth the glass must be given the necessary form before use. Mechanical processing distorts the structure of the material surface and subsequent careful polishing cannot completely eliminate the damage. In space it is possible to use such a tool as surface tension of the fluid. Using this scientists are hoping to obtain at once glass in such forms as optical lenses. It is also conceivable, although not in the immediate future, that it will be possible to fabricate optical elements for telescopes of unprecedented size. (Moscow, Pravda (in Russian), July 16, 1978, p. 6 [Article by A. Pokrovskiy: "The 'Fotony' are Flying Over the Earth"].)

"What is it that we find attractive in space?" continues A. Yu. Malinin. "It is primarily that under weightlessness conditions we can plan on obtaining materials which are perfect in structure and more uniform in composition than those which for the time being can be obtained from factories on earth. We hope that space technology will help us."

"For the first time in world practice a program for the 'Salyut-6' provided for obtaining not only large crystals, but also another class of materials coming into still broader practical use—film structures. For this purpose a layer of another substance (or the same substance but with modified properties) is built up on the semiconductor surface; it has a thickness from tens of A to tens of microns and a geometry which is rigorously stipulated in advance. In space, where thermal processes, especially heat transfer, occur differently than on the earth, it becomes possible to create more perfect surfaces and transitional layers."

"I would like to mention one peculiarity of our apparatus," states the experiment director V. T. Khryapov. "Prior to this in space use was made of only one method for obtaining materials for electronics—the growing of crystals by the method of directed crystallization. We made provision for using three other methods. In particular, we intend to obtain film structures both by the method of a gas transport reaction and by the moving solvent method." (Moscow, Pravda (in Russian), July 23, 1978, p. 6 [Article by Yu. Apenchenko: " 'Kristall'. . ."].)

Academician Glushko discussed manned flight and the industrialization of space in a September 3, 1978 "Izvestiya" article.

An interview was held with Academician Valentin Petrovich Glushko, the founder of Soviet rocket construction, the leader in development of the powerful liquid-fuel rocket engines used in launching satellites, manned space ships and orbital stations. In particular, he dealt with the question of how long man can remain in space. All this will be a step toward the industrialization of space. An increase in the duration of expeditions is admissible only gradually, as experimental data are accumulated, objectively confirming such a possibility with the mandatory condition that the crew's health and performance is maintained. If the results are positive, in the near future it appears reasonable to settle on a year's duration of the main expeditions as a maximum. (Moscow, Izvestiya (in Russian), Sept. 3, 1978, p. 2 [Article by B. Konovalov: "Mastering the Space 'Continent' "].)

The importance of maneuvering and docking a space ship is discussed in this September 8, 1978 "Krasnaya Zvezda" article.

The maneuvering of a ship near an orbital station, its transfer from one docking unit to another, is in itself very interesting. It considerably broadens the possibilities of space navigation and is a prototype of future broad transport operations in space. In such a way, by means of space ferries, it is possible, for example, to carry out communication between several orbital stations, extraterrestrial factories or even entire settlements, which very possibly will appear in the future. As space becomes more "lived in" there will be ever-broader use of such operations as redocking, maneuvering in orbit. The present experiment is an important step on this path. (Moscow, Krasnaya Zvezda (in Russian), Sept. 8, 1978, p. 1.)

In September 1978, Tass announced the decoration of Soviet cosmonaut Bykovskiy and East German cosmonaut Jaehn.

Moscow, September 10, Tass.—Soviet Cosmonaut Valeriy Bykovskiy was decorated with the Order of Lenin for the successful space flight in the orbital research complex Salyut-6-Soyuz and for courage and heroism shown during the flight. It was Valeriy Bykovskiy's third space flight. In the past he was twice awarded the highest title, the title of Hero of the Soviet Union. (Moscow, Tass (in English), 1437 GMT, Sept. 10, 1978.)

BERLIN, September 11, Tass.—General Secretary of the Socialist Unity Party of Germany Central Committee, President of the GDR State Council Erich Honecker has awarded the Karl Marx Order to Soviet Cosmonaut Colonel Valeriy Bykovskiy and conferred on him the honourary title of Hero of the German Democratic Republic. The first GDR cosmonaut, Lieutenant Colonel Sigmund Jaehn, was awarded the Karl Marx Order and had the title of Hero of the German Democratic Republic conferred on him. He also received the title of Pilot-Cosmonaut of the GDR.

The two cosmonauts were awarded for their outstanding services and for their courage and heroism displayed during the successful space flight and also for their participation in the fulfillment of the programme of scientific and technical studies on board the orbital space complex Salyut-6-Soyuz-29-Soyuz-31. Earlier, twice Hero of the Soviet Union Valeriy Bykovskiy was awarded the Soviet Order of Lenin while Sigmund Jaehn was awarded the title of Hero of the Soviet Union. (Moscow, Tass (in English), 1307 GMT, Sept. 11, 1978.)

Cosmonaut Leonov described the future use of orbital stations in a October 25, 1978 "Pravda" article. Feoktistov discussed it further in the November 4 "Pravda."

Moscow, October 25, Tass.—The construction in the Soviet Union of orbital stations with changeable crews and of the freight ship Progress marks a step forward on mankind's way toward interplanetary travel. Soviet scientists regard such complexes as man's highway to outer space, Soviet Cosmonaut Aleksey Leonov writes in Pravda today. He was the first man in the history of astronautics to have made a space walk and took part as the commander of the Soviet crew in the Soyuz-Apollo test project (1975).

In Leonov's opinion stations similar to Salyut-6 may become "cosmodromes in orbit" launching sites, where cosmonauts will take part in putting together interplanetary ships and testing their systems and pass through a period of acclimatisation, so to say. It has been estimated that a journey to Mars and back will take two years and eight months. Such a long expedition will require not only technical preparation but also a solution of a number of other problems, Leonov writes. Then he touches upon such problems of long space flights as psychological compatibility of crew members and "sensory hunger."

In designing Soyuz spaceships and Salyut orbital stations Soviet specialists showed great concern for the cosmonauts. But still greater demands will naturally be made on the design of interplanetary ships, Aleksey Leonov writes. (Moscow, Tass (in English), 0838 GMT, Oct. 25, 1978.)

The sixth representative of the "Salyut" family occupies a special place—it is the first second-generation station. Its operation has confirmed that it is feasible to carry out long expeditions and that it is possible in principle to change crews during a flight and to improve the research program not only from one expedition to another, but also more flexibly during flights. The appearance of the extra docking unit which provided the maneuverability also prompts thoughts of a more general kind. Will blocks of stations joined together like a honeycomb emerge in the future? That is not impossible. At any rate, designers have food for thought here. Nevertheless, when you look to the future—and not such a distant future—and imagine the "Salyuts" of the next, the third generation, you do not see a simple increase in size as their main feature. In fact, this main feature has not been hidden from the designers' view and is becoming increasingly marked with each station: we are striving to insure the maximum automation of on-board operations and to make them continuous. This is the main way of improving the stations.

I want to stress here that however fully we may succeed in automating the control of spacecraft, as the duration of flights increases, the role of the cosmonauts on board will become increasingly significant. For what purpose are we actually seeking to increase the duration of flights? To ascertain the potential for working and living in near-earth space. With time, that area of space will become a boundless field of practical activity. Then it will no longer be individual crews but large collectives of people who will have to work in space; and they will turn to the experience of the first long-term expeditions as a primary source.

In our work we proceed from the premise that the creation of long-term orbital stations is the main direction to be followed in the development of spaceflight. All the "Salyuts" from the first to the latest—the sixth—have demonstrated their ability to serve the most varied purposes and diverse sciences: astronomy and physics, geology and medicine, electronics and geography. (Moscow, Pravda (in Russian), Nov. 4, 1978, by Prof. K. Feoktistov.)

A paper written in 1978 for the U.S.S.R. Academy of Sciences discussed the development of an emergency rescue capsule for orbital stations. Another paper discussed rescue in dense layers of the atmosphere.

Considerable attention is being devoted to flight safety in the design of all manned space systems [2]. In the future, when the duration of orbital station missions will increase, and the increased activity of mankind in space will lead to multiple "earth to space station orbit" shuttle flight operations, it will not be expedient to execute the orbital mission with the shuttle craft docked with the station.

Along with this, because of the increased complexity of station systems and stuctures, the probability of the occurrence of emergency situations on board a space station is increased. In a number of cases, the docking of an orbital station to a shuttle rescue ship can prove to be impossible. For this reason, it is expedient to have independent means of safely returning the station crew by means of special space vehicles (capsules) along with the regular transport ships.

The results of planning and structural design work on a possible variant for a rescue capsule, located on board an orbital station, are given in this paper. The major function of the emergency rescue capsule consists in providing for the evacuation of the crew of the orbital space station in the case damage occurs which cannot be eliminated. (System for the Emergency Rescue of Cosmonauts from Orbital Stations [Saskos]. Moscow Trudy Odinnadtsatykh Chteniy, Posvyashchennykh Razrabotke Nauchnogo Naslediya I Razvitiyu Idey K. E. Tsiolkovskogo (Kaluga, 14–17 September 1976), Sektsiya "Problemy Raketnoy I Kosmicheskoy Tekhniki" in Russian, 1978, pp. 101–108. [Paper by Belonogov, Ye. K., Ivarovskiy, S. A., Grigorovich, V. K., Zatsepin, A. Y., Ignat'yev, V. V., Sokolov, V. A., Tarasov, V. N., and Minenko, V. Ye., USSR Academy of Sciences, Commission for the Development of the Scientific Heritage of K. E. Tsiolkovskiy).

One of the important problems arising in investigating trajectories for the entry of hypersonic vehicles into the dense layers of the atmosphere is a reduction of the accelerations which arise. K. E. Tsiolkovskiy devoted great attention to the recovery of a vehicle and crew from the effect of accelerations in various flight stages. An effective means for reducing accelerations during atmospheric entry is improvement of descent module lift properties. A hypersonic vehicle with the aerodynamic quality $K \sim 1$ can glide in the atmosphere after descent from a satellite orbit with an acceleration not exceeding 1.5, and therefore, the entry of such a vehicle into the earth's atmosphere with a near-circular velocity is not critical from the point of view of the dynamic loads which arise. However, with a velocity much less than first cosmic velocity with aerodynamic quality the accelerations upon entry into the dense layers of the atmosphere may be not only greater than during descent from a satellite orbit, but may exceed the admissible level $n_{ad}x3{-}4$ by several times. In this paper the author examines the influence of changes in aerodynamic characteristics of the vehicle and initial conditions on the maximum acceleration during entry into the dense layers of the atmosphere.

Expressions are derived making it possible to evaluate the effectiveness of a change in initial conditions and control parameters for reducing the maximum velocity head. The article gives the results of computations of the influence of variation of initial conditions relative to the nominal conditions on the maximum acceleration n_{max}. Qualitative conclusions are drawn concerning the structure of optimum control of a descent module in the neighborhood of the initial point. It is shown that upon entry of hypersonic vehicles into the dense layers of the atmosphere with a subcircular velocity the acceleration which can arise may considerably exceed the admissible level. A method is proposed for evaluating the effectiveness of decreasing the maximum acceleration by means of aerodynamic control and change in the initial conditions. Figures 3; references 4: 3 Russian, 1 Western. (Recovery of Hypersonic Vehicles Entering Into the Dense Layers of the Atmosphere at a Subcircular Velocity. Moscow Trudy Odinnadtsatykh Chteniy, Posvyashchennykh Razrabotke Nauchnogo Naslediya I Razvitiyu Idey K. E. Tsiolkovskogo. (Kaluga, 14–17 September 1976), Sektsiya "Problemy Raketnoy I Kosmicheskoy Tekhniki" in Russian, 1978, pp. 90–99 Filat'yev, A. S.)

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A paper, written for the U.S.S.R. Academy of Sciences Commission for the Development of the Scientific Heritage of Tsiolkovskiy in 1979, discussed possible future interplanetary flights. Another paper discussed supplementary fuel possibilities for spacecraft.

A study was made of the problem of an interplanetary flight carried out with an intermediate flight around Mars or Venus. It is shown that a perturbation maneuver near these planets will make it possible to reduce energy expenditures and improve the kinematic characteristics of the trajectory. As the optimality criterion the authors employed the total characteristic velocity required for realization of the flight. As a result of the computations it was possible to find the total flight time and the optimum calendar times for the accomplishment of such flights. An evaluation of the effectiveness of correction of an Earth-Mars-Saturn trajectory is made. (Prediction of Some Schemes for Interplanetary Flights to the Outer Planets, Moscow Trudy 12-kh Chteniy, Posvyashch. Razrab. Nauch. Naslediya I Razvitiyu Idey K. E. Tsiolkovskogo, Kaluga, Sekts. Mekh. Kosmich. Poleta in Russian 1979, pp., 17–26 Leshchenko, A. V., Kotin, V. A., Papkov, O. V. [From Referativnyy Zhurnal, 62. Issledovaniye Kosmicheskogo Prostranstva, Otdel'nyy Vypusk No. 10, 1979 Abstract No. 10.62.312 by V. Rudenko].)

The article discusses the problem of using the mass of waste water from the onboard systems of a space vehicle as a supplement to the main fuel components of an oxygen-hydrogen rocket engine. It is proposed that this ballast mass be diverted into the rocket engine combustion chamber. A functional diagram of the afterburning system is shown. An expression is derived for computing the decrease in the relative expenditure of components of the main fuel. The experimental results confirm a thrust increment with afterburning of the additional mass. (Energy Possibilities of a Space Vehicle Using Oxygen-Hydrogen Fuel, Moscow Trudy 12-kh Chteniy, Posvyashch. Razrab. Nauch. Naslediya I Razvitiyu Idey K. E. Tsiolkovskogo, Kaluga, 1977, Sekts. K. E. Tsiolkovskiy I Probl. Raket. I Kosmich. Tekhn. in Russian 1979, pp. 116–121 Zabotin, V. G., Levin, V. Ya., Pervyshin, A. N. [From Referativnyy Zhurnal, 62. Issledovaniye Kosmicheskogo Prostranstva, Otdel'nyy Vypusk No. 10, 1979, Abstract No. 10.62.365].)

Space oceanography has been developed to improve navigation and fishing, according to a February 14, 1979 article. The technical aspects of light absorption by the ocean were discussed in an April 1979 article.

The launching of the specialized oceanographic satellite "Cosmos–1076" is making it possible to check out the methods for investigating the world ocean using space techniques. This experiment will make it possible to check out methods for complex synchronous measurements of hydrophysical parameters. The data obtained during flight from special control-calibration sea and ocean polygons will make it possible to evaluate the accuracy of remote measurements and "tie them in" to real physical processes.

The most important of the practical problems are an increase in the effectiveness of navigation and fishing. In the interests of navigation provision is made for the routine collection of hydrometeorological information from extensive areas of the world ocean. Data on the direction and velocity of the wind in the near-water layer, waves, on zones of generation and direction of movement of storms and hurricanes will help in selecting the optimum navigation routes. It is still more important to have routine information on ice conditions in the Arctic and Antarctic basins, and in particular, for year-round operation of the Northern Sea Route.

The determination of color and temperature anomalies at the ocean surface, according to data from remote sounding, will make it possible to refine the boundaries of frontal zones and other physical formations in the surface layer of the ocean, with which, as a rule, are associated regions which are promising for the fishing industry.

Experimental space oceanography is taking only the first steps. But it can be said with assurance that the means and methods for remote sounding from aboard space vehicles will give oceanologists a powerful tool capable of raising the study of the world ocean to a considerably higher level and making extensive use of these advances in the interests of the national economy of the country. (Commentary on "Cosmos–1076" Mission, Moscow, Pravda (in Russian), Feb. 14, 1979, p. 6 [Article by B. Nelepo: "A Look at the Ocean from Orbit"].)

One of the principal directions in marine optics is a study of the properties of the substances constituting sea water by optical methods. In particular, this involves an analysis of the absorption spectra of different programs introducing a contribution to the total absorption of light by sea water. These spectra are obtained using such instruments as the "Volna" spectrophotometer, whose high-quality optical-electronic system makes possible reliable registry of the small absorption characteristic for sea water. But the relative error in measurements in the case of very small absorption is high, which is a result of the short length of the measurement base. An increase in this base is impossible, since this would require a considerable increase in the dimensions of the instrument. The absorption spectrum of sea suspension is obtained as the difference between the spectra of the absolute values of the absorption indices of sea water and its filtrates. For solving the problems in light field theory it is necessary to measure the absorption index λ directly at sea; in this case the requirements on measurement accuracy are low and it is sufficient to obtain λ values averaged for volumes with linear dimensions of the order of several tens of meters. For these purposes it is possible to use methods based on measurements of divergence of the light vector. The laser method makes it possible to obtain λ values for a fixed wavelength averaged for the surface layer of the sea with a thickness of several tens of meters. This method, being a noncontact method, makes it possible to obtain large volumes of data while the ship is on course. Selection of the working wavelength is dependent on the nature of the investigated object. For example, in a quantitative study of the distribution of chlorophyll in surface waters it is desirable to select $\lambda = 675$ nm, which corresponds to the main maximum of chlorophyll absorption. (Determining Index of Light Absorption in Sea Water, Moscow, Okeanologiya (in Russian), vol. 19, No. 1, 1979, pp. 168–174 [Article by B. F. Kel'balikhanov, S. Yu. Rusanov and G. D. Shnyrev, Institute of Oceanology, "Methods for Determining the Index of Light Absorption in Sea Water"].)

Yuri Zaitsev commented on the future programs for the orbital space station in March 1979.

There has been discussion in Western scientific circles of Soviet plans to develop massive "factories in space," where such alloys and crystals would be produced. But Yuri Zaitsev, head of the Institute of Space Research at the Soviet Academy of Sciences, says such programs are far in the future.

"In the near future, work with manned flights will of course remain focused on long-life orbital stations with changing crews. "The design of the station and of the transport ships could be modified, but the principle will remain the same," Zaitsev said.

"Maybe as time passes orbital stations will become larger, but by how much is a moot point. In any case, large stations are hardly practical at the present stage. For the time being, it is more practical to employ comparatively small and cheap, but well-tested stations of the Salyut type, which offer broad possibilities for varying research programs." (By Colin Baker, Time-Life News Service, Moscow, Mar. 16, 1979.)

Several articles discussed the planned development of radio and gamma telescopes which could be used in space.

Is this a fantasy? Yes, but not completely without basis. After all, space vehicles have already blazed paths to Mercury, Venus, Mars and Jupiter. Plans call for flights to the more remote planets of the solar system. Entire scientific complexes are operating in circumterrestrial orbit. Astronomical observations are being made from these. Scientists are also planning to put in circumterrestrial orbits automatic telescopes which do not require the constant presence of man. In exactly the same way is it possible to put a telescope into orbit around the sun?

Existing space technology makes it possible to say seriously that in space it is possible to construct a telescope of any size. After all, weight does not exist there and it is technically feasible to assemble the necessary construction of any size from individual parts.

Visualize a radio telescope dish with a diameter, for example, of ten kilometers. In the focus of this space radio eye there will be vehicles receiving signals and transmitting them to earth. Also there is an apparatus controlling, by radio command from the earth, the shape of the dish itself, since each of its elements can be turned fully in the necessary direction.

Such will be the nature of the telescope planned by a group of Soviet scientists and will be encountered by the space traveler in circumsolar orbit in the not too distant future. The unusual conditions will enable man to make a detailed study of everything which is in our universe—through which even electromagnetic waves penetrate only in 20 billion years. (Sovetskaya Rossiya, Mar. 24, 1979.)

Soviet scientists plan to build a system of radio telescopes in outer space. Parts of the system will be launched into the sun's orbit by rockets, where they will dock with one another. The telescope systems thus formed will have a mirror dozens of kilometers in diameter. The systems will be separated from one another by a distance of thousands of millions of kilometers. This will make it possible to register radiation emanating from remote and small objects and measure the distance to them. Scientists hope that such a system of radio telescopes will help receive signals from extraterrestrial civilizations. Moscow, World Service (in English), 0430 GMT, Apr. 6, 1979.)

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Modern cosmonautics has exerted a substantial influence on the development of many branches of science, including the most ancient—astronomy. The possiblility of carrying out observations beyond the limits of the atmosphere has made it "omniwave." It is understandable that only investigations in the entire range of electromagnetic radiation can give a true idea concerning astrophysical processes. Evidence of this is the successes of infrared, ultraviolet and X-ray astronomy. And now a new direction is developing more and more actively—gamma astronomy.

However, the sensitivity, angular and energy resolution of existing gamma telescopes are inadequate for carrying out a broad search for new discrete sources and reliably tying them in to known astronomical objects. Therefore, the USSR Academy of Sciences, taking into account the great scientific and technical experience accumulated by Soviet scientists in the field of exoatmospheric investigations and space instrument making, has planned a program which is directed to the development of gamma astronomy observations in our country. In order to carry it out, a number of scientific research organizations, headed by the Space Research Institute USSR Academy of Sciences, have proceeded to the joint development and creation of a complex of measuring instrumentation, including a gamma telescope with a high sensitivity and a high angular resolution. The weight of the telescope is about 1½ tons.

It is clear that such a telescope can be installed and operated only on special space stations whose creation only a few years ago seemed dubious. However, now this problem no longer seems so unreal. The "Salyut-6" space station has been in orbit more than 1½ years. Several crews have already worked aboard it and the "Soyuz" transport ships and the "Progress" freighters have been repeatedly docked to it. All this makes it possible to regard the elements of the "Salyut"-"Soyuz"-"Progress" complex as a prototype of a space platform for gamma astronomy observations. (Moscow, Pravda (in Russian), Apr. 27, 1979, p. 3 [Article by V. Kirillov-Ugryumov and A. Gal'per: " 'Yelena' and Others"].)

According to this April 1979 article, visual observations from the Salyut 6 can contribute to the space station program. The article also announced a planned global navigational space system.

In addition to photographing different sectors of the earth's surface the "Salyut-6 crew also made extensive use of visual observations. Whereas earlier such observations in many cases were of a facultative nature, now they are becoming one of the most important points in the program. It is well known that the human eye is capable of distinguishing hundreds and even thousands of color hues. But on brief flights the cosmonaut's vision does not succeed in adapting to such an extent that it could be classified as a reliable space tool. However, on longer flights the visual observations of the crew can be simply irreplaceable. The flier-cosmonaut V. Kovalenok notes, for example, that from orbit it is possible to see deep ocean ridges and submerged islands, which cannot be discovered even on an extremely sensitive photographic film. And since this is so, it is easy to visualize what enormous profit can come from a well-trained man with his capacity for routine selection of the object of observation, instantaneous processing of information and its analysis and rapid transmission of the already evaluated data to the earth.

A new page in the history of sea navigation was opened in 1978. The thousandth satellite of the "Cosmos" series was launched into orbit. This was a space navigation beacon by means of which it was possible, with a high degree of accuracy, to determine the geographical coordinates of its position at any point on the earth regardless of weather conditions. The signals received and processed by the shipboard apparatus make it possible to determine the position of a vessel relative to the satellite, its coordinates.

The first navigational satellite has already been of significant service to seamen, especially to the crew of the atomic-powered "Sibir'." A global navigational space system will evidently be created with time. This system includes several satellite-beacons moving in polar orbits, surface control-measurement centers and receiving-computing apparatus mounted on shipboard. It is believed that such a system is capable of replacing the enormous number of surface beacons now employed in marine navigation, will increase the accuracy of navigational measurements, and accordingly there will be an increase in the economy and safety of navigation. (Moscow, Sovetskiy Voyn (in Russian) Nov. 6, 1979, by A. Vlasov, in April 1979.)

In the May 19, 1979 "Pravda," R. Sagdeyev wrote about the future potential of manned orbital stations. The May 22, 1979 "Pravda" also contained an article on space stations. On June 20, 1979, Tass carried comments by Professor/Cosmonaut Feoktistov on future generations of the Salyut 6.

SPACE EXPERT EXAMINES USES FOR MANNED ORBITAL STATIONS

Under the heading "Laboratories in Orbit" a 1,200-word article by R. Sagdeyev, director of the USSR Academy of Sciences Space Research Institute, discussed the possible future use of manned orbital stations for astronomical and astrophysical research and noted the need to develop new highly reliable telescopes for this purpose. Sagdeyev then discussed the prospects of radioastronomy research from orbital stations and the potential for the development of space technology (obtaining various crystals under conditions of weightlessness) and finally mentioned the need to develop both multipurpose and specialized orbital stations. (Moscow, Pravda (in Russian), May 19, 1979 p. 3.)

The Salyut-6 station is, of course, not the ideal environment for prolonged work in space. So far, it contains only the most essential equipment to enable a man to live and work. In the future, the stations will be complexes of much greater size, and greater comfort. But today we must obtain sufficient data so that the designers will be able to create the necessary comfort level in them for the crew. It is noisy in the Salyut-6 station. There are always dozens of fans running, apparatus being switched on and off. All this, the cosmonauts say, is the normal background to which they long adapted themselves. The doctors think otherwise. Noise has an effect on man which is partly independent of his awareness of it. (Moscow, Domestic Service (in Russian), 0200 GMT, May 22, 1979) [Unattributed commentary: "Today in Orbit"].

Moscow, June 20, Tass.—"In our work we proceed from the understanding that the creation of lasting orbital stations is the main line of the development of cosmonautics. All the Salyut stations, beginning from the first one to the present, sixth one, have demonstrated their ability to serve science for human benefit," Cosmonaut Konstantin Feoktistov said.

Speaking of the Salyut-6 orbital station which has been functioning in space for more than one year and a half, Professor Feoktistov pointed out: "On the whole we are satisfied with the work of the orbital complex."

In the family of the Salyut stations, the sixth one has taken a special place, in Feoktistov's view—this is the first station of the second generation. "The emergence of an additional docking unit which ensured a greater scope for manoeuvre suggests ideas of a more general aspect. Whether [as received] multiblock stations will appear in the future? Linked between themselves in the honeycomb fashion? [as received] Well, it is not precluded. At all events, the designers have something to think about," he told journalists.

"And nevertheless, turning to the future, and not so distant one, and visualizing Salyut stations of the next, third, generation, one sees their main peculiarity not only in the increase of volume. The main peculiarity was not unknown to the designers earlier, and it becomes increasingly manifest from station to station: We seek to automatize to the maximum the working processes on board and make them continuous. This is the way to perfect the stations." (Moscow, Tass (in English), 0958 GMT June 20, 1979.)

July 18, 1979 Tass carried a discussion of radio telescopes.

Moscow, July 18, Tass.—Special Tass correspondent Nikolay Zheleznov reports from the Flight Control Centre: The first radio telescope was unfolded in orbit on July 18. It was installed aboard the Salyut-6 and its antenna was moved out into open space. Previously not a single spacecraft had on board such a big and sophisticated scientific instrrument. Why should scientists need a telescope at a height of 400 kilometres if it is known that the earth's atmosphere is transparent to most of the types of radiation? Answering this question Nilolay Kardashev, corresponding member of the USSR Academy of Sciences and one of the men in charge of the project, said that the further advance of science into the depth of universe is inconceivable without increasing the size of ground antennae.

Thanks to the pooling of efforts by radio astronomers of the USSR, the USA, Australia and other countries, it has been possible in recent years to conduct synchronous observations of remote galaxies with the help of radio telescopes separated by great distances, which offered a chance to increase, as it were, the area of antennae. The present event in orbit marks a new stage in the development of astrophysical methods. The KRT-10 radio telescope will be used together with the 70-metre Crimean radio telescope.

During synchronous radio sessions the distance between them will vary from 400 to 10,000 kilometres. Physicists have calculated that such a radio bridge will be equal to the possibilities of a radio telescope with a size comparable to the earth's diameter. (Moscow, Tass (in English), 1947 GMT, July 18, 1979.)

August 17, 1979 Tass discussed the Isparitel space experiment which tested welding in weightless conditions.

KIEV, August 17, Tass.—Experiments on the Isparitel unit, held aboard the orbital Salyut-6 station by Cosmonauts Vladimir Lyakhov and Valery Ryumin have become a major stage in the development of the program of Soviet exploration in space technology. The new equipment designed for the study of processes of evaporation and condensation of different materials in conditions of weightlessness was designed at the Yevgeniy Paton Electrical-Welding Institute of the Academy of Sciences of the Ukraine. The USSR's leading scientific-research welding and special electrometallurgy centre is known all over the world. In the recent time the centre spread the sphere of its explorations to outer space.

The task before us was to check the principled possibilities of different methods of welding in conditions of weightlessness, said Deputy Director of the Institute Daniil Dudko. The beginning was laid by the Vulkan unit, with the help of which Cosmonaut Valeriy Kubasov ten years ago conducted aboard the Soyuz-6 spaceship the first technological welding experiment in outer space.

The next stage was the designing of compact electrobeam "guns" for the space experiment Zarnitsa and for the Soviet-French project Araks. A soldering iron and a number of other tools for work aboard space stations were designed in collaboration with space explorers. Scientists of the institute participated in explorations in space technology of metals in the course of the Soviet-American Soyuz-Apollo experiment.

The new Isparitel unit made it possible to obtain new batches of specimens with silver coatings, which in the future will be subjected to special physical exploration. This experiment is of great significance for further exploration of outer space. During long operation of space stations and spaceships the need sometimes arises of restoring thermal protective, optical and other coatings which for different reasons lose their properties to that extent or other. Such an operation was held at the Salyut-4 station. The cosmonauts smelted with the help of strong current an aluminum ball and were able to improve the properties of the mirror of the orbital solar telescope.

The technology used in the Isparitel makes it possible in principle to apply coatings from different metals, alloys and even non-metallic materials. There is no doubt that this technology is in for a great future in outer space, the scientists said in conclusion. (Moscow, Tass (in English), 2022 GMT, August 17, 1979.)

A Tass statement and a speech by L. I. Brezhnev emphasized the importance of manned flight.

Of course, there is still a great deal to be done to improve working and living conditions in orbit. It is necessary, for instance, to pay special attention to improving conditions for sleep, the doctors say. The sport facilities in orbit, which were found to play a decisive part in preparing cosmonauts for return to the earth, need to be reorganized. In the long run it will be possible, perhaps, to turn the veloergometer into a real track bicycle so that cosmonauts could make circular runs inside a spacious cylinder. This will be possible to stimulate, if only insignificantly, a gravitation effect on the cosmonauts' organism, an effect that is badly needed by space travellers. (Moscow, Tass (in English), August 23, 1979, Nikolay Zhelenov.)

[Speech by Leonid Ilich Brezhnev, general secretary of the CPSU Central Committee and chairman of the Supreme Soviet Presidium on September 7 at Kremlin ceremony awarding medals to Cosmonauts Vladimir Lyakhov and Valeriy Ryumin]

Indeed, it is not for nothing that specialists in many countries are now talking about the presence of real conditions for a lengthy, perhaps even permanent activity by man in space, about how the basis is being created for future interstellar flights.

Dear Comrades Lyakhov and Ryumin: For successful fulfillment of the program of the longest space flight in history on board the Salyut-6-Soyuz orbital scientific research complex and the courage and heroism displayed during this you have been given the highest awards of the homeland. You have been awarded the titles of heroes of the Soviet Union with the presentation of orders of Lenin and gold star medals. Comrade Lyakhov has been awarded also the title of "Pilot Cosmonaut of the USSR." (Moscow, Pravda (in Russian), September 8, 1979, p. 1.)

Academician Paton noted three areas for development in Soviet space technology in an interview in October 1979.

From my point of view they (space technologies) will be developed along three basic directions. The first concerns construction and assembly operations in space. Already in the 1960's S. P. Korolev expressed the idea of using so-called "transforming" structures which are folded into small parcels on earth and then transported and deployed in space. Weightlessness creates some interesing possibilities here. Welding would be required in the assembly of such structures.

Weightlessness can also help in the creation of structures and compartments of future orbital stations made of very thin layered metal and even foil.

When all of this passes beyond the stage of laboratory testing and into practical cosmonautics on the scale of production (factories in orbit), the time will come for welding operations in space. And in the future the welding and cutting of metals and other materials will be required for distant interplanetary flights and then for building orbital living and production centers.

However, we will return to tasks closer at hand. The longer an orbital station is in operation, the more often restoration and repair problems will arise—this is the second direction in developing space technologies. It is better to restore units where they are functioning in space rather than to deliver new units from earth.

The third direction is the development of space technolgies that would make it possible to obtain unique materials in orbit. (Kiev, Pravda Ukrainy (in Russian), Oct. 16, 1979, p. 3 [Interview with Boris Yevgen'yevich Paton, director of the Institute of Electrical Welding and president of the Ukrainian Academy of Sciences: "Space Technologies"].)

Former cosmonaut Sevast'yanov discussed the future development of space stations in an interview in December 1979.

In near-earth orbits there will be scientific stations designed for studies of the earth and near-earth space as well as remote regions of the universe using astronomical instruments placed beyond the earth's atmosphere. These are geophysical stations. They will be able to study the earth's natural resources and monitor the natural environment. These will be manned laboratories where instrumentation can be refined to the point where all operations can be done automatically. And then there will be modular scientific stations. Each module will have its own special purpose. A module will be equipped with the apparatus necessary for a definite research program and will be delivered to a station composed of other compartments and modules, including living and sleeping quarters, etc. Throughout an expedition the modules could be exchanged. In overall size and volume each module would be like our Salyut station. This is the first direction.

The second is to solve technological questions—that is to say, technology in space and, in the future, factory-stations, on board which technological processes impossible under the conditions of gravity will be conducted. On these stations, for example, crystals needed for electronics will be grown.

In space we will be able to obtain super-pure pharmaceuticals.

Another goal is to obtain composite alloys.

In near-earth orbits there will be atomic electric power stations and electric power stations with solar panels (converting solar energy into electricity and transitting this energy to earth perhaps by laser).

From these proposed directions it is evident that one of the major purposes for orbital stations is to serve man's economic activity. Tallin, Sovetskaya Estoniya (in Russian), Dec. 5, 1979, p. 3 [Interview with V. I. Sevast'yanov, USSR pilot-cosmonaut and candidate of technical sciences: "Earth—Space—Earth"].)

The development and importance of the radio telescope is again pointed out in this November 1979 article.

Associated with the flight of the "Salyut-6" orbital station is such an important success of Soviet space technology and radio electronics as the launching and unfolding in near-earth orbit of the KRT-10 radio telescope. Its very name stands for "space radio telescope with a 10-meter antenna." The unfolding of the KRT-10 space radio telescope is not only the first step in radio astronomy outside the atmosphere. It is also the beginning of a fundamentally new trend in work in space—the creation of sectional and folding structures, in particular, of such equipment as large antennas for various purposes.

An important contribution to the creation of large sectional structures in space will be made by cosmonauts. The EVA of V. V. Ryumin and V. A. Lyakhov and the work done by them have demonstrated that cosmonauts will play an important role in assembly, in investigations and in repair operations.

The complexities involved in constructing large space antennas do not appear to be insurmountable. Meanwhile the advantages of these antenna systems are attracting the very keen interest not only of radio astronomers, but of communications specialists, geophysicists and power engineers as well. This is a token of the fact that after the first step, after the creation of the first 10-meter radio telescope in the world, the KRT-10, there will follow further studies aimed at the creation of larger and further improved systems. (Moscow Nauka I Zhizn' (in Russian), Nov. 11, 1979, pp. 2-6 [Article by Yu. Danilov, doctor of physical and mathematical sciences, Yu. Kuleshov, engineer, and V. Rudakov, candidate of technical sciences: "The First Space Radio Telescope"].)

Director of the Space Research Institute of the Academy of Sciences, Sagdeyev speculated on future industrialization in space in a December 1979 interview.

In the past few years our country has taken a great step forward in the conquest of space. We have attained practically continuous manned operations in orbit; at the end of last year there was what I would call an explosion of new information on the chemistry of Venus; and there is an entire group of wonderful young scientists concentrating in the space sciences. Also among the most significant achievements is the sharp increase in the role of international cooperation in space research, which has been evident in the flights of the CEMA cosmonauts and in the cooperation with various other countries in the realization of scientific and technical programs in space, including the joint work with our French colleagues.

I am certain that in the next 5-10 years a vast amount of industrial activity will begin in orbit. Toward that end we must prepare not only technology but men as well. (Tallin, Sovetskaya Estoniya (in Russian), Dec. 7, 1979, p. 1 [ETA Report: "On Space Topics"].)

There is still another important factor which forces us not to hurry with the creation of large stations. I have in mind the disproportion between the rate of collection of scientific information and the rate of its processing. This is a matter of great concern to scientists, designers and cosmonauts. Now when a crew works aboard an orbital station for one month we obtain so much scientific information about the earth, its environment and natural resources that years are required for its processing. And the problem here is by no means a matter of miscalculations. It is simply that former data processing methods do not correspond to the new situations.

An increase in the useful life of orbital stations is inseparably associated with an increase in the reliability of all its systems, instruments and assemblies. This is no simple problem. Even on the earth not one machine operates continuously over the course of many months and years; it requires preventive maintenance and the replacement of parts. In space the situation is saved by the crew. It can be said with complete assurance that the prolonged operation of the "Salyut-6" station became possible only due to the consmonauts. It has no equal with respect to the volume of preventive maintenance and repair-restoration work carried out aboard it.

But in order for such work to be carried out effectively, the possibilities for reconstruction must be incorporated in advance in the design of the station and its equipment. Otherwise even the most experienced crew can do nothing.

Long-term observations of the ocean from space made it possible to establish the possibility of directing ships of the fishing fleet into regions where fish were plentiful. The first experiments indicated great promise and great material advantage. All this indicates that in the years immediately ahead there can be a considerable increase in the economic effectiveness of such investigations. This requires communication between the crews of orbital stations and ships at sea, a knowledge of their coordinates and the coordinates of the regions of fish concentration closest to them. (Moscow, Vodnyy Transport (in Russian), Dec. 25, 1979, p. 3 [Article by M. Chernyshov: "They are studying the ocean from space"].)

B. Nelepo commented on the development of an automatic ocean surveillance system in a December 1979 interview. Nelepo was also interviewed for Aviation and Cosmonautics journal on ocean surveillance from space.

"In the end," B. Nelepo, director of the Ukrainian Academy of Sciences' Marine Hydrophyscial Institute, added, "it all comes down to the development of a continuously operating automatic system for observing the ocean from space. Why is it of interest to study not only the ocean surface layer but its depths as well? And is it possible to look into [the depths]? When Vitaliy Sevast'yanov told specialists that from orbit he could see the Mid-Atlantic ridge, many were doubtful. Now it is well known that the ocean surface layer repeats the underwater relief, and that there are "rises" and "falls." Internal waves, which, as a rule, are propagated within the ocean depths but sometimes also emerge onto the surface, can serve as a kind of "projector" for studying the depths.

"In all, our task lies in learning to recognize the useful signals that the ocean sends to us. What kind of observations can be conducted, let's say, in the infrared range? In what cases would it be preferable to use radio waves? In what part of the spectrum would it be most advantageous to photograph with color film? All of these questions require a lot more work. The experience accumulated to date in this field is already extensive. In particular, the specialized oceanographic satellite "Cosmos-1076," which was launched not long ago, has yielded much useful information. Other space vehicles are also in operation. But in order to develop them further, the aid of our cosmonauts is unconditionally necessary."

The specialization of orbital stations will evidently follow as these problems are solved. The matter of including scientists and specialists in crews can arise in some stage.

The mastery of space is occurring at a rapid rate. In principle it is already possible to realize projects for orbital stations with a crew of 10-20 or more men.

Should we not be concerned with such projects at the present time? Have the possibilities of existing stations been exhausted?

It seems that the economic and scientific-technical advantage of large stations for the time being still appears doubtful and the possibilities of our "Salyuts" are far from exhausted.

The "Salyut" stations are being improved simultaneously in several directions. Their operational and research capabilities are being expanded, their reliability is increasing and the conditions for life and work of the cosmonauts are improving. Progressively improved in design, they differ quite significantly. (Aviatsiya i Komonautika (Aviation and Cosmonautics) No. 12, Dec. 1, 1979, pp. 40-41.)

1980

On January 8, 1980 Tass carried a talk given by a Soviet scientist on the Soyuz-T spacecraft and its newest features.

Soyuz-T (is to be in) flight in tandem with the Salyut-6 station for several months. This is understandable. Before manufacturing such spacecraft in series the experts wanted to test all its systems and various dynamic operations. For example, shortly there is to be an orbit correction exercise. This will change the orbit of the entire complex, consisting of the docked Salyut station and Soyuz-T spacecraft. The exercise will reveal how much propellant is consumed by the craft's new propulsion system. The propulsion system is one of its new features. It is based on the same technical concept as is the propulsion system of the orbital station. The propellant tanks of the (cruise) engine and of the control and docking engine have been connected to form a single system. This makes it possible to use propellant supplies more flexibly. In the past, an over-expenditure of the propellant (in) the attitude control system could compel the (craft) to return to earth, even if there was still plenty of propellant in the (cruise) engine. In the new spacecraft this will not be so.

Another innovation is the on-board computer complex. It has taken over many of the duties that up to now have had to be discharged by the crew: Flight control, systems control and flight data treatment and transmission to earth. And another notable feature: Once in orbit, Soyuz-T spread out the panels of its solar batteries. In the past, transport craft did not have such batteries. Now solar batteries have enchanced the new craft's energy potential. Its attitude control systems too have been improved, assuring more efficient (apposition) of the sun, the earth and stars, which is very important to space navigation. Other onboard systems have likewise been modified and the general layout inside in the craft has been improved.

As I said, the new craft is to be subjected to prolonged testing in space. The testing actually began with its launching. The new spacecraft took three days to link up with the station, but one day like a manned spacecraft and not two days like a progress unmanned series. [sentence as heard] During these three days specialists put it through its paces and tested its capacity for automatic maneuvers for ordering its attitude in space and for docking operations. Only after the designers had given it excellent marks for all these exercises was it allowed to link up with the Salyut 6 orbital station. Soyuz-T embodies many recent scientific and technological advances but this does not mean that the next manned flight will necessarily be made in these new craft. The previous Soyuz spacecraft—there have been more than 30 of them—acquitted themselves very well and they will continue to be used to carry cosmonauts into orbit in the immediate future. As for the present trial flight, it is a dress rehearsal with the spacecraft embodying many novel technical features. (Moscow, World Service (in English), 1000 GMT, Jan. 8, 1980 [Talk by (Ryma Karleyeva) of the flight control center on the Soyuz-T; recorded in Russian fading to English translation].)

On January 17, 1980, Tass announced preparations for an international conference on navigation satellites.

Equipment for receiving navigational information via space satellites is being installed on merchant ships, fishing vessels, research vessels and other ships sailing in the waters of the Soviet Far East. Arkadi Lavrov, head of the Service of Security of Navigation in the Soviet Far East, told a Tass correspondent that the use of satellites sped up several times the delivery of information and improved the quality of communications. It no longer depends on ionospheric conditions. Preparations are underway in the USSR for the implementation of the international convention envisaging the setting up of a communications system with the use of satellites for the needs of navigation being created on the Soviet Union's initiative. Socialist, capitalist and developing countries are participants in the convention. Its implementation will make it possible to remove the danger of accidents and will make for more effective navigation of ships. (Moscow, Tass (in English), 1053 GMT, Jan. 17, 1980.)

In January 1980, a French journal speculated on the future capabilities of the Salyut system. In February 1980, the journal interviewed Soviet cosmonaut Klimuk on the Soyuz-T.

The haste with which the Soviets want to know about the latest arrangements seems to reflect their desire to launch "Salyut 7" in a few months should the utilization of "Salyut 6" prove to be no longer possible—in order to prevent delays in the execution of their manned missions. . . . The utilization of such a "Soyuz" as the locomotive of a space train will appear to be natural. In the past we have denounced as illogical the operation to refuel "Salyut" from a supply vehicle so that "Salyut" engines can be used for trajectory maneuvers; the vehicle docked with "Salyut" can use the fuel much more simply in order to arrive at the same result.

Nonetheless we cannot help being struck by the hesitation of the Soviets for more than one year to use the propulsion system of "Salyut 6." This system is known to have malfunctioned in 1978: last February Lyakhov and Ryumin found a station fallen to 270 kilometers above the earth. They spent much effort to repair its propulsion system, or more exactly, its tank pressurization apparatus, in the course of a very long operation which at the time was presented as a success. But never since has the propulsion system of the "Salyut" station been utilized; the orbital station has never been put back into the planned orbit. The explanation may be that even though the propulsion system has been repaired, the Soviets still entertain some doubts as to its functioning in prolonged service. They are, therefore, intending to keep the equipment in good shape for the last operation, which will consist of making the station reenter through the atmosphere over the Pacific at the end of its career. (Parris, "Air and Cosmos" (in French), Jan. 26, 1980 by Albert Ducrocq.)

Soviet cosmonaut Petr Klimuk revealed in an interview with Air & Cosmos correspondent Pierre Langereux some new information about the Soyuz-T transport ship and Soviet intentions for its use as part of the total Salyut-Soyuz system.

First he noted that Soyuz-T has been designed to serve as either a freight transport ship or as a manned transport carrying two cosmonauts, "as has become the rule on Soviet transport vehicles."

Emphasizing that "in the immediate future Soyuz-T will not totally replace" the conventional Soyuz, Klimuk indicated that the USSR will continue to make use of all three types of transport ships at its disposal: Progress, Soyuz and Soyuz-T. The new Soyuz-T could be piloted by an all-Soviet crew only whereas the conventional Soyuz, in which the role of "pilot" is rather limited, will continue to fly international crews. The reason for maintaining this duality, according to Klimuk, lies in the time necessary to train cosmonauts to fly Soyuz-T: at least 1 year's training with the flight simulator will be required (and Klimuk, an experienced cosmonaut, said that it took him about 1½ years to master the new vehicle).

Soyuz-T incorporates some very clear improvements over the conventional Soyuz ship although its exterior design and total mass have been changed relatively little. According to Klimuk, the two most insignificant improvements are in piloting the vehicle (thanks to an on-board digital computer which processes all flight operations data and displays them on a single screen) and in the ship's maneuvering capabilities (thanks, in large part, to the unified propulsion system similar to that of the second generation Salyut station).

Klimuk also revealed that the ship's autonomous flight mode was improved with "the possiblitity of equipping the new vehicle with solar panels." In saying that the use of solar panels was not for the present foreseen because the transport ship could rely on energy provided by the Salyut-6 station, he contradicted earlier comments made by former cosmonaut and chief Salyut designer Konstantin Feoktistov, who had indicated to Soviet central press correspondents that Soyuz-T was now equipped with two solar "wings" [see Izvestiya Dec. 21, 1979, p. 6, Pravda Dec. 20, 1979, p. 6 and Trud Dec. 20, 1979, p. 6, reported in JPRS 75111]. (Paris, Air & Cosmos (in French), No. 800, Feb. 16, 1980, pp. 50–51 [Article by Pierre Langereux: "New Revelations About the Soyuz-T Vehicle"].)

On February 25, 1980, Tass carried a description of improvements in sea communication with the use of satellites.

Moscow, February 25, Tass.—A program for a broad use of spacecraft for sea communication and shipping has been outlined in the Soviet Union. With this aim, a system is created providing for the use of artificial earth satellites of the Cosmos type. An all-union Morsvyazsputnik (sea communication satellite) organization has been set up under the USSR Ministry of Merchant Marine. It will be charged with processing data received by means of Soviet and international artificial earth satellites necessary for ensuring communication and navigation on high seas. The satellite system will eliminate breaks of many hours in radio-communication between sea-going ships and ports caused by magnetic storms and other radio interference. The "ship-satellite-ground station" radio bridge will speedily and effectively link subscribers.

Already now, big Soviet ships under construction are equipped with satellite communication apparatuses, due to which the control of ship traffic will be more effective in future. The communication system will be used also in navigation. Satellites may become outer space beacons. The USSR is a member of the INMARSAT international satellite communication organization, which was set up recently. The convention on its establishment came into force in July last year. The aim of INMARSAT is the control of a system, which is to be created on an international basis for ensuring communication between sea-going vessels and coast by means of space satellites. (Moscow, Tass (in English), 1334 GMT, Feb. 25, 1980.)

Cosmonaut Kobasov discussed scientific advances on the Salyut 6 space station in his April 26, 1980 "Pravda" article.

The further development of cosmonautics will undoubtedly be coupled with the construction in near space of large objects such as base orbital stations with large crews, giant radio-telescope antennas, solar power engineering systems, interplanetary ships with an extended operating period, and so on. This presents space technology with a limitless field of activity.

Even the most preliminary technical and economic calculations show that repairing objects that are permanently in space will make it possible to achieve a substantial increase in their service life and the reliability of their normal functioning and, correspondingly, the effectiveness of their utilization. This, in particular, is indicated graphically by the experience gained during the extended operation of the "Salyut-6" station, on which the eighth crew is now working. By the way, L. Popov and V. Ryumin have used considerable knowledge and exerted much effort on preventive maintenance of the station. (Pravda (in Russian), Apr. 26, 1980, by Cosmonaut V. Kobasov.)

A member of the Academy of Sciences wrote about the methods used to study the Earth's surface and atmosphere from space.

The use of the microwave range of radio waves for observing the earth from space considerably supplements optical and IR observation methods and in some cases is superior to these methods. The advantages are attributable to the specific properties of the interaction between microwaves and the environment. Radio waves in the centimeter and especially in the decimeter ranges are virtually not absorbed and are not scattered by clouds, so that these radio observations can be considered all-weather. Due to the relatively small absorption in the ground, snow and ice, radio observations make it possible to "look" into the earth, in the future to depths of several tens and possibly hundreds of meters. In some cases observations in the radio range make it possible to avoid the screening effect of vegetation. Active and passive methods are discussed, including the fundamental physical principles. The results of a number of experiments are presented. Together with the data obtained by other methods, the data from radio observations can be used in meteorology, oceanography, in the study of ice and snow covers, in geology, agriculture and forestry, land improvement, water management and other fields. Appropriate instrumentation will be carried aboard both satellites and aircraft. A major problem in this field is that of spatial resolution. At present this resolution is inadequate and must be increased by considerably enlarging the antenna to several tens of meters or by employing special methods for shaping and processing signals, which is not possible in all cases. In the immediate future the microwave range will be used in . . . (Moscow Issledovaniye Zemli Iz Kosmosa (in Russian), Nov. 1, 1980, pp. 95-105 [Article by N. A. Armand, Institute of Radio Engineering and Electronics USSR Academy of Sciences].)

This May 23, 1980 news item explored the possible benefits of developing a separate greenhouse on the space stations.

In the opinion of specialists the definitive solution to the problem lies in creating on board a biologically closed cycle. For this purpose it is essential to get not only the higher plants but also algae and even some microorganisms to function and develop normally in space. An experiment has already been performed aboard the station with chlorella, which is the main contender for the role of the fundamental link in a system for biological cleansing of the atmosphere. Scientists believe that basically the conditions for long-term operation of the station do not hinder the vital activities of chlorella. But a few anomalies do persist and these must be cleared up.

The following idea is being put forward. Plants and other biological subjects should not be located in the station itself but rather a special module should be developed for this, along the lines of the progress specialized cargo craft. Such a greenhouse attached to the station could function for quite a long time providing cosmonauts with air, water and food. (Moscow, Domestic Service (in Russian), 0000 GMT, May 23, 1980.)

Lt. Gen. Shatalov gave an interview in June 1980 on the future of manned space missions.

Lt. Gen. Vladimir Shatalov, leader of the cosmonaut training programme, gave an interview to Hungarian journalists on the future of space flights. As he said, Soviet scientists and specialists have for long been dealing with questions of further development and have designated a number of directions and tasks for the coming years.

The first such task is increasing the capacity of the spaceship. The spaceship can at present seat only two cosmonauts thus on the space station—which is large enough for a crew of many more cosmonauts—only the constant two-member crew and at the most two visitors, can work. A very great stress and burden falls in this way on the members of the constant crew and besides this there is no possibility for researchers of special qualifications to work in the space station for a long time. At present both cosmonauts have to be familiar with the operation and guidance of the spaceship—because of light security reasons—in roughly the same way.

If for example spaceships with three cosmonauts will be launched, the third cosmonaut can be such a specialist who will have to deal with these factors only in a minimal degree, and who can thus devote the majority of his time to specialized research. (Budapest MTI (in English), 1100 GMT June 5, 1980, Budapest, June 5 (MTI)—Csaba Kis, MTI's correspondent in Moscow reports.)

According to this Wall Street Journal editorial, the Soviet Union announced it had a satellite that was invisible to radar detection in 1980.

SOVIET STEALTH

The recently announced "new" stealth technology for making aircraft invisible to radar is neither new nor proprietary with the U.S. military.

In mid-summer of 1962 the Soviet Union made a public announcement that it was launching a Cosmos earth-orbiting satellite which would be invisible to radar detection. The satellite was successfully launched and it carried on board a radio transmitter which could be used to confirm that it was in orbit.

The Sohio radio satellite tracking station under my direction in Cleveland successfully tracked this device by its radio beacon for several weeks and obtained good orbital elements. NORAD, whose responsibility it is to maintain surveillance of orbiting satellites and missiles, learned of Sohio's successful measurements. They requested the radio tracking information and got it. Normally radio tracking data are not needed by NORAD unless radar and optical methods prove ineffective. Apparently this was the case. After approximately two months the radio transmitter in the satellite ceased to operate and the space vehicle became invisible to all methods of tracking.

The recent boastful announcements by Defense Secretary Brown make me feel very insecure because I know the Soviets publicly demonstrated a radar-invisible earth-orbiting satellite 18 years ago.

A.L. JONES.

(Cleveland Wall Street Journal, Sept. 15, 1980.)

Tass described metallurgical experiments conducted on board the Salyut 6 which could lead to repair and construction work in space.

KIEV, November 27, Tass.—Soviet specialists can if necessary apply thermal protective, optical and other coatings on various equipment in space as well as to obtain materials and articles by evaporation and condensation methods. This conclusion has been drawn by the scientists of the Yevgeniy Paton Electric Welding Institute of the Ukraine Academy of Sciences. They have summed up the preliminary results of the space experiment which was carried out recently on the installation "Isparitel" (evaporator) which they created.

The reliable functioning of the "Isparitel" on board the station Salyut-6 and the practical results of the experiment substantiate our assertion, Academician Daniil Dudko, deputy director of the institute, told a Tass correspondent. Specimens of coatings out of gold, silver, copper and other metals applied onto plates by the space flight participants Leonid Popov and Valeriy Ryumin have been brought back to earth.

Sufficiently high quality of the coatings confirms the correctness of the scientific ideas of the Soviet researchers, the academician stressed. Weightlessnesss proved most troublesome for the researchers. It is not an easy thing to evaporate metal. It is necessary to turn it into liquid which is to be converted into metallised vapours in space and to be uniformly deposited onto a surface. To keep liquid metal in the crucible is difficult, too. Nevertheless the problems have been solved and the space vacuum which exceeded by several orders the one that has been artificially created on earth served as an ideal medium for the realisation of the technological process.

The experiment in space was a kind of prologue not only to a number of repairing-restorative operations but also to assembly work in space, Daniil Dudko said. The scientists foresee a possibility of delivery of metals, and plastics to orbit and of their conversion into thin-walled elements which will serve as building blocks of flying laboratories and, in the future, whole factories for the production of unmatched materials. (Moscow, Tass (in English), 1300 GMT, Nov. 27, 1980.)

Appendix II

AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE UNION OF SOVIET SOCIALIST REPUBLICS CONCERNING COOPERATION IN THE EXPLORATION AND USE OF OUTER SPACE FOR PEACEFUL PURPOSES

The United States of America and the Union of Soviet Socialist Republics;

Considering the role which the U.S.A. and the U.S.S.R. play in the exploration and use of outer space for peaceful purposes;

Striving for a further expansion of cooperation between the U.S.A. and the U.S.S.R. in the exploration and use of outer space for peaceful purposes;

Noting the positive cooperation which the parties have already experienced in this area;

Desiring to make the results of scientific research gained from the exploration and use of outer space for peaceful purposes available for the benefit of the peoples of the two countries and of all peoples of the world;

Taking into consideration the provisions of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, as well as the Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space;

Encouraged by the progress made in the course of mutually agreed activities pursued under the Agreement Between the United States of America and the Union of Soviet Socialist Republics Concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes, signed May 24, 1972;

In accordance with the General Agreement between the United States of America and the Union of Soviet Socialist Republics on Contacts, Exchanges and Cooperation in Scientific, Technical, Educational, Cultural, and Other Fields, signed June 19, 1973, and in order to develop further the principles of mutually beneficial cooperation between the two countries;

Have agreed as follows:

ARTICLE 1

The Parties will continue to develop cooperation in such fields of space science and applications as space meterology; study of the natural environment; exploration of near earth space, the moon and the planets; space biology and medicine; satellite search and rescue systems; and, in particular, will cooperate to take all appropriate measures to encourage and achieve the fulfillment of the

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SOURCE: Senate Commerce, Science, and Transportation Committee, Hearings, NASA Authorization for Fiscal Year 1979, 1978, pt. 3, p. 933–935.

Summary of Results of Discussion on Space Cooperation Between the U.S. National Aeronautics and Space Administration and the Academy of Sciences of the U.S.S.R. dated January 21, 1971, periodically renewed.

ARTICLE 2

The Parties will carry out such cooperation through their appropriate national agencies by means of mutual exchanges of scientific information and delegations, and meetings of scientists and specialists of both countries, and also in such other ways as may be mutually agreed. Joint Working Groups may be created for the development and implementation of appropriate programs of cooperation.

ARTICLE 3

The Parties will take all necessary measures for the further development of cooperation in the area of manned space flight for scientific and practical objectives, including the use in joint flights of compatible docking and rendezvous systems derived from those developed during the experimental flight of Apollo and Soyuz spacecraft in July 1975. Joint work in this direction will be carried out in accordance with the Agreement Between the U.S. National Aeronautics and Space Administration and the Academy of Sciences of the U.S.S.R. on Cooperation in the Area of Manned Space Flight dated May 11, 1977.

ARTICLE 4

The Parties will encourage international efforts to resolve problems of international law in the exploration and use of outer space for peaceful purposes with the aim of strengthening the legal order in space and further developing international space law and will cooperate in this field.

ARTICLE 5

The Parties may by mutual agreement determine other areas of cooperation in the exploration and use of outer space for peaceful purposes.

ARTICLE 6

This Agreement shall enter into force May 24, 1977 and shall remain in force for five years. It may be modified or extended by mutual agreement of the Parties.

Done at Geneva this 18th day of May 1977 in duplicate in the English and Russian languages, both equally authentic.

For the United States of America

CYRUS R. VANCE.

For the Union of Soviet Socialist Republics

A. GROMYKO.

AGREEMENT BETWEEN THE USSR ACADEMY OF SCIENCES AND THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION OF THE USA ON COOPERATION IN THE AREA OF MANNED SPACE FLIGHT

In accordance with the Agreement on Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes between the

USSR and the USA, dated May 24, 1972, and taking into account the results of discussions held in Washington, October 19–22, 1976, between the delegation of the USSR Academy of Sciences, headed by the Chairman of the Intercosmos Council of the USSR Academy of Sciences, Academician B. N. Petrov, and the delegation of the National Aeronautics and Space Administration of the USA, headed by the NASA Deputy Administrator, Dr. A. M. Lovelace, the Academy of Sciences and NASA agree to undertake the following steps for further development of cooperation between the USSR and USA in the exploration and use of outer space for peaceful purposes.

I. STUDY OF THE OBJECTIVES, FEASIBILITY AND MEANS OF ACCOMPLISHING JOINT EXPERIMENTAL FLIGHTS OF A LONG-DURATION STATION OF THE SALYUT-TYPE AND A REUSABLE "SHUTTLE" SPACECRAFT (SALYUT-SHUTTLE PROGRAM)

In view of the fact that the long orbital stay-time of the Salyut-type station and the capabilities of the Shuttle spacecraft commend their use for joint scientific and applied experiments and for further development of means for rendezvous and docking of spacecraft and stations of both nations, the two sides agree to establish two joint working groups (JWGs) of specialists, charging them with studying the objectives, feasibility and means of carrying out a joint experimental program using the Soyuz/Salyut and Shuttle spacecraft:

A JWG for basic and applied scientific experiments.

A JWG for Operations.

Within 30 days after the Agreement becomes effective, the sides will inform each other of the initial leaders and composition of these JWGs. The work of both Joint Working Groups should begin simultaneously. The composition of the JWGs can be changed or enlarged at any time as necessary. Appropriate subgroups can be formed.

In their studies, the JWGs should proceed on the assumption that the first flight would occur in 1981. The final date would be set in the course of the joint work.

FIRST PHASE OF THE JOINT WORKING GROUPS' ACTIVITY

The following preliminary project documents should be prepared within 6–12 months after the agreement comes into effect:

Preliminary proposals for scientific experiments;

Preliminary technical proposals for carrying out the program;

Preliminary schedules for implementing the program.

SECOND PHASE OF THE JOINT WORKING GROUPS' ACTIVITY

The JWGs should prepare the following definitive documents within one year of joint work in the second phase:

A technical description of the joint program and its realization;

A scientific program for the joint flight;

A schedule for conducting the joint work;

An organizational basis for implementing the program;

A list of additional joint technical documentation which may be required.

The sides will make the final decision on implementing the program at the end of the second phase of the JWGs' activity.

The working period of the JWGs in the first and second phases of their activities can be shortened.

Each side will consider the accommodation on its spacecraft of payloads proposed by the other side for flight in the Shuttle-Salyut program. Such accommodations will be undertaken where both sides agree that the payloads concerned are of mutual value and interest.

II. CONSIDERATION OF THE FEASIBILITY OF DEVELOPING AN INTERNATIONAL SPACE PLATFORM IN THE FUTURE (INTERNATIONAL SPACE PLATFORM PROGRAM)

Both sides recognize that no commitments are made at this stage concerning the realization of any project for creating an international space platform.

The sides agree to establish a Joint Working Group of specialists for preliminary consideration of the feasibility of developing an International Space Platform on a bilateral or multilateral basis in the future.

The JWG will carry out its work on the basis of studies conducted by each side independently and also by the two sides jointly, proceeding from each of the following stages to the next as may be mutually agreed;

Define at the first stage the scientific and technical objectives which would warrant the use of such a space platform.

Consider possible configurations appropriate to the objectives identified.

Formulate proposals on the feasibility and character of further joint work which may be desirable in this field.

At the first stage of its activity, the group will work in close coordination and contact with the JWGs set up to consider ways to realize the Salyut-Shuttle program.

The sides will appoint the initial leaders and members of the JWG for this program within two months after the agreement goes into effect. This JWG should formulate preliminary proposals on possible scientific-technical objectives which could be achieved by an international station one year after beginning its work.

This agreement comes into force at the moment it is signed by both sides.

For the U.S.S.R. Academy of Sciences

A. P. ALEKSANDROV.

For the National Aeronautics and Space Administration of the U.S.A.

A. M. LOVELACE.

Appendix III

TABLE OF SOVIET SPACE LAUNCHES 1957-80*

This table includes all launches whose payloads reached sustained Earth orbit or escape beyond Earth, with an identification of individual payloads as best can be determined. It also includes those few failures (of an unknown larger number) which have been acknowledged at governmental level, but not including failures rumored in the public press even if the latter in some cases are perhaps accurate. The list also includes suborbital flights such as vertical space probes when the vehicles used equal or approach the size of vehicles used for orbital flight, if these suborbital flights have been acknowledged in Soviet releases.

The starting point in building the table has been to use Tass releases for the basic listing with orbital elements. At a second level, related orbital numbers have been filled in with what is mostly NORAD data, but further filtered through and often supplemented with additional facts or estimates by the Royal Aircraft Establishment, Farnborough (RAE). If in a few cases RAE did not have particular orbital data, then the Goddard Satellite Situation Report has been used, which also is largely derived from NORAD. Finally, if all these sources failed, estimates have been made, based upon analogous flights.

The table supplies a comprehensive account that goes well beyond any other officially published account based upon Soviet announcements or upon direct readings from space by radar skin tracking or optical observation or radio signal intercepts. Therefore it is important to convey some sense of the approximate degree of accuracy. The table could be developed only through an extended synergistic development of the individual chapters of the full study with the program descriptions for each category of payload, and the chronological listing of these flights in this appendix. In the descriptions which follow, that degree of certainty or uncertainty will be traced.

It must also be recognized that any such table is only the best which can be done at a particular time. Fresh data may become available even for early flights, such as official Soviet histories, new insights by Western analysts, and disclosures about current activities which then make it possible to understand better the precusors. Also, of course, objects in orbit may decay from air resistance, and this affects the table for earlier years.

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*Compiled by the late Charles S. Sheldon II, with computer assembly by L. Delores McCain.

THE HEADINGS

Payload name

For the most part, these are announced by Tass. However a few flights have not been acknowledged by the Russians, yet have been discovered by Western sensors. Also, in a large number of flights there are implicit payloads which have not been named by the Russians, although often their functions are described by Tass. The most obvious are the Tyazheliy Sputnik payloads, which are heavy satellite launch platforms from which a Zond or probe is launched to deep space, or to eccentric orbit, or to geocentric synchronous orbit. Another common type of unacknowledged payloads are pickabacks carried along with major payloads. Most typically, military photographic payloads often carry a functional section which is separated some time during the flight, usually toward its end, which can be found by radar and visually, and in some cases from radio signals. Often some years later, the scientific findings from the experiments carried in these pickabacks are published in the open literature by the Russians. In connection with biological experiment flights which seem to use essentially the same spacecraft hardware shells as the military picture takers, some of these supplemental and separable pickaback payloads have been put on public display. Another kind of castoff object from others of the military photographic flights are the maneuvering engines which are used to adjust orbits during the flight. These have not been listed in this table as payloads. In summary, payload names are specifically known or generically indicated.

Designator

The designator column lists an abbreviation of the COSPAR international numbering system. In the early years, each flight was identified by a sequence of one or more Greek letters in lower case (but here spelled out) plus an Arabic numeral in sequence for each separately tracked object connected with a given launch. After the early years, each flight was given a sequential Arabic numeral designator, plus a capital Roman letter for each separate tracked object connected with a given flight. This is firm information except for a few pickabacks where there may be doubt. Flights not attaining orbit do not have designators.

Launch date

As far as can be determined, the listed date is based upon Greenwich Mean Time (GMT), also known as Zulu time. In the case of some suborbital flights relying on Tass reports, which are based on Moscow time, 3 hours ahead of GMT, the date listed may be a day ahead of GMT date.

Site

Some Soviet launches come from the Baykonur Cosmodrome, which in the West is usually referred to as Tyuratam (TT), the railway station closest to this site in Kazakhstan. Additional launches come from the Northern Cosmodrome, which in the West is referred to as Plesetsk (PL), again, the nearest large settlement, on the railway between Moscow and Archangel. Finally a smaller number of space launches come from the Volga Station, called in the West, Kapustin Yar (KY), on the lower reaches of the Volga River below Stalingrad. The launch sites have been identified with a high degree of certainty. Usually the launch site can be derived from the orbital inclination and the repetitive patterns which appear here. In other cases, one must go to additional source data, the so-called "Goddard two line elements" which give the longitude of the zero revolution equatorial crossing, whose Earth trace should answer whether it passes through one of the three separate Soviet launch sites.

Launch vehicle

The text of the main report develops in detail the characteristics, capacities, and interrelationships among the various Soviet launch vehicles. In brief, as each new first stage vehicle has come into use, it has been assigned a sequential capital Roman letter, skipping those letters also used as suffixes in existing vehicles. Because it is not always possible from available public information to define and describe all the upper stages used, the first combination brought into use is called "1," and if this is markedly modified, the new version becomes "2." In some cases, there is a third designator if the 1 or 2 versions of the launch vehicle have an extra final stage added (a third or fourth stage), and this is indicated by an additional Roman letter in lower case, such as "e" for escape, "m" for maneuvering, "r" for retro stage. In other cases a maneuvering or retro capability may be integral to the payload, and is not given a letter designation. This nomenclature system first appeared in the TRW space log and is used in many countries of the world. It has been used in preference to the Department of Defense "SL" designators because the DOD system has not been completely described in public and conveys no sense of vehicle structure or interrelationship. The designators used are firm for most of the flights with minor exceptions tested in the main text which discusses any obscurities.

Weight

All weights are given in kilograms. Only on a few occasions have the Russians announced specific weights, so in the majority of cases, it has been necessary to estimate the weight, followed by a question mark in the table. The estimates are derived from what is known about the capacities of the launch vehicles (see the main text), and adjusted to approximate what might be expected considering the orbital height and inclination to the Equator. In some cases, not all the lifting capacity of the launch vehicle is used, most obviously in the case of Interkosmos flights using the "C" vehicle. Where estimated weights were used by the RAE, these have been adopted for this table, with several departures. In some cases, this table has assumed a different launch vehicle from that assumed at the RAE. In other cases the RAE did not carry any estimate. In still other cases, the RAE made a different assumption as to whether a military photographic mission carried a maneuvering engine or a pickaback, which in turn makes a difference of roughly 400 kilograms in the assumed weight of the total payload before separation into individual flight components. It should also be noted that where the weight of a Tyazheliy Sputnik is given, this is before separation of the final Zond or other payload, and hence includes the orbital platform plus the payload and its fueled probe rocket, but does not include the weight of the separated and expended carrier rocket which put the Tyazheliy Sputnik into its parking orbit. Overall, the estimated weights at least are probably of the right order of magnitude and perhaps within 20 percent of the true weight. One might also note that in the physics sense, once the flight begins, Earth surface weight becomes meaningless, and "mass" would be a better description.

Apogee

This figure is in kilometers above the surface of the Earth and represents the high point of the orbit, usually as the orbit was initially determined, and before air friction began the process of decay. In some cases, a significant later maneuver adjusted the orbit sufficiently that a second and different apogee is also listed. In a very few cases, labled as such, the orbit may be that around the Moon, Venus, or Mars. In another group of cases, the figure is not in kilometers but in astronomical units (1 a.u. equals the mean distance between Earth and Sun).

Perigee

This figure is the one corresponding to apogee but represents the lowest point of the orbit above the surface of the Earth. The same exceptions referenced above apply to the Moon, Venus, Mars, and solar orbits. These latter orbits have a separate nomenclature which has not been used in the headings of this table for reasons of space. (Apcynthion and pericynthion respectively, for lunar orbits, apares and periares for Mars orbits, aphelion and perihelion for solar orbits, no universally recognized labels for Venerian orbits, and apoapsis or periapsis as generalized labels.)

Inclination

This refers to the slope of the orbit to the Equator of Earth (or the Moon or planet), also reported as the maximum latitude of the ground trace in degrees north and south of the Equator. In the case of heliocentric (solar) orbits, the figure given is the inclination to the plane of the ecliptic, the plane defined by the orbit of the Earth around the Sun.

Period

This is stated in minutes to complete one orbit of the Earth (or Moon or planet), except in the case of heliocentric orbits, where the figure is given in days (indicated with a reference 5) instead of minutes.

Also in this column is a letter symbol to give the source of the orbital data listed: reference 1 for Tass, reference 2 for RAE, reference 3 for Goddard Space Center, and reference 4 for estimate.

Sources for orbital elements (apogee, perigee, inclination, and period) were discussed above. It should be noted there are almost always slight differences between Soviet and Western orbital elements as published for a given object, both because of limitations on measuring accuracy, on differences of time as to when the measurements were made, and possibly differences in computer program assumptions about the geoid, the true shape of the Earth.

Decay date

This is based on GMT, as carried in the RAE or Goddard reports, unless a suborbital flight, which relies on Tass information which may or may not match GMT time. In a few cases, the real date of decay is not known to Western agencies, and has been estimated by them.

It might be noted that the label "decay" is shorthand for several kinds of reentry. Over a period of time ranging from hours in low orbit to years, even millenia, in high orbit, air drag affects the orbit, the result is to slow the spacecraft, which permits it to fall to a lower orbit, where it travels faster than it did before in its higher orbit, until finally it feels the full effects of the dense layers of the atmosphere, where it may burn up, and in some cases reaches the surface of the planet (or the Moon).

In other cases, decay may carry a different connotation, for the payload fires a retrorocket which drops the orbit more precipitously down to a level where the dense atmosphere can complete the task of ending the flight, either by burning up, or by making a survivable landing.

Days life

This is a simple arithmetic difference between launch date and decay date, usually printed by the RAE, but calculated directly if not published by the RAE.

Mission

The mission identification is occasionally announced by Tass, but more often has been estimated in the already mentioned synergistic relationship with the rest of the study. By grouping all the flights with similar characteristics, it is usually possible to determine the main purpose of the flight. But sometimes differences of mission turn on fairly subtle indicators, and some caution is required. Clues come from the orbital elements. Each mission class usually has one or more of a limited number of launch inclinations at which it is flown. Likewise, there are typical orbital patterns of altitude for photographic missions, electronic ferrets, navigation satellites, weather satellites, geodetic satellites, early warning satellites, communications satellites of several classes, and so forth. Overall, most missions can be determined reliably, but a few missions remain obscure, either indefinitely, or until repetitive patterns finally give confidence that the first flights of that pattern are understood. There is always an outside chance that a purpose has been hidden by choosing external flight characteristics which would mislead. It should also be remembered that a flight may have multiple purposes (i.e. military photography, electronic ferreting, engineering tests, and scientific experiments in a single payload). Also early vehicle tests can be counted arbitrarily as vehicle tests per se or as precursors to some later application.

Remarks

This column is provided to supply supplemental information where appropriate, although in less detail than as carried in the tables and chapters of the main text. For example, the names of astronauts, the fact of docking, the nature of scientific experiments is given as an aid to the reader.

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Unstated		May 16, 1957	KY	SS-2	2,196	211up			(1)	May 16, 1957	0	Biological probe	5 dogs recovered.
Unstated		Aug. 3, 1957	TT	SS-6	(?)				(1)	Aug. 3, 1957	0	ICBM test	Soviet claim to first ICBM flight in world.
Sputnik 1	57-Alpha 2	Oct. 4, 1957	TT	A	84	947	227	65.1	[1] 96.2	Jan. 4, 1958	92	First test satellite	Transmitted 21 days.
Sputnik 2	57-Beta 1	Nov. 3, 1951	TT	A	508 net 6,508 Gross	1,671	225	65.3	[1] 103.7	Apr. 14, 1958	162	Biological satellite	Carried dog Layka, not recovered.
Unstated		Feb. 21, 1958	KY	SS-3	1,515	473up			(1)	Feb. 21, 1958	0	Geophysical probe	
Sputnik 3	58-Delta 2	May 15, 1958	TT	A	1,327	1,881	226	65.2	[1] 106.0	Apr. 6, 1960	691	Geophysical satellite	Comprehensive laboratory first to carry solar cells.
Unstated		Aug. 27, 1958	KY	SS-3	1,690	452up			(1)	Aug. 27, 1958	0	Biological probe	
Unstated		Sept. 19, 1958	KY	SS-3	1,515?	473up			(1)	Sept. 19, 1958	0	Biological probe	
Unstated		Oct. 31, 1958	KY	SS-3	1,515?	473up			(1)	Oct. 31, 1958	0	Biological probe	
Luna 1 (Mechta)	59-Mu 1	Jan. 2, 1959	TT	A-1	361 net 1,472 gross	1,318au	0.978au	0.01	[2,5] 450			Moon strike	Missed Moon by 5,000–6,000 km Jan. 4, 1959, entered solar orbit.
Unstated		July 2, 1959	KY	SS-2	2,000	241up			(1)	July 2, 1959	0	Biological probe	Dogs Otvazhnaya, Snezhinka Rabbit, Marfusha.
Unstated		July 10, 1959	KY	SS-2	2,200	211up			(1)	July 10, 1959	0	Biological probe	Dogs Otvazhnaya, ———.
Luna 2	591-X 1	Sept. 12, 1959	TT	A-1	390 net 1,511 gross	400,000			(1)	Sept. 13, 1959	1	Moon strike	Struck Moon 435 km from visible center (1W, 30N)
Luna 3	59-Theta 1	Oct. 4, 1959	TT	A-1	435 net 1,533 gross	476,500	40,300	73.8	[2] 22,700	Apr. 20, 1960	199	Moon pictures	Photos of farside of Moon returned by radio after flyby Oct. 10, 1959 at 6,200 km.
Korabl Sputnik 1	60-Epsilon 1	May 15, 1960	TT	A-1	4,540	369 675	312 290	65.0 65.0	[1] 91.2 [1] 94.3	Sept. 9, 1962	847	Man precursor	Recovery failed, accidentally moved to higher orbit, part fell Manitowoc, Wis., Sept. 9, 1962 more fell Oct. 15, 1965.
Unstated		June 15, 1960	KY	SS-2	2,100	221up			(1)	June 15, 1960	0	Biological probe	Dogs Otvazhnaya, ———, rabbit.
Unstated		June 24, 1960	KY	SS-2	2,100?	212up			(1)	June 24, 1960	0	Biological probe	
Korabl Sputnik 2	60-Lambda 1	Aug. 19, 1960	TT	A-1	4,600	339	306	65.0	[1] 90.7	Aug. 20, 1960	1	Man precursor	Dogs Strelka, Belka recovered (first orbital recovery).
Unstated		Sept. 16, 1960	KY	SS-2	2,100?	210up				Sept. 16, 1960	0	Biological probe	
Unstated		Sept. 22, 1960	KY	SS-2	2,100?	210up				Sept. 22, 1960	0	Biological probe	
Mars		Oct. 10, 1960	TT	A-2e	640?					Oct. 10, 1960	0	Mars	Launch failure announced by United States.
Tyazheliy Sputnik					6,475					Oct. 10, 1960	0		
Mars		Oct 14, 1960	TT	A-2e	640?					Oct. 14, 1960	0	Mars	Launch failure announced by United States.
Tyazheliy Sputnik					6,475?					Oct. 14, 1960	0		
Korabl Sputnik 3	60-Rho 1	Dec. 1, 1960	TT	A-1	4,563	265	188	65.0	[1] 88.6	Dec. 2, 1960	1	Man precursor	Dogs Pchelka, Mushka, burned on reentry.
Tyazheliy Sputnik 4	61-Beta 1	Feb. 4, 1961	TT	A-2e	6,483	328	224	65.0	[1] 89.8	Feb. 26, 1961	22	Intended to launch Venera	Failed to eject Venera.
Venera	61-Beta 1				644?	328	224	65.0	[1] 89.8	Feb. 26, 1961	22	Venus	
Venera 1	61-Gamma 1	Feb. 12, 1961	TT	A-2e	644	1.019au	0.718au	0.58	[2,5] 300			Venus	Passed Venus at 100,000 km May 19–21, 1961 but contact lost Feb. 27, 1961.
Tyazheliy Sputnik 5	61-Gamma 3				6,475	282	229	65.0	[2] 89.6	Feb. 25, 1961	13	Launched Venera 1	
Korabl Sputnik 4	61-Theta 1	Mar. 9, 1961	TT	A-1	4,700	249	184	64.9	[1] 88.5	Mar. 9, 1961	0	Man precursor	Dog Chernushka recovered.
Korabl Sputnik 5	61-Iota 1	Mar. 25, 1961	TT	A-1	4,695	247	178	64.9	[1] 88.4	Mar. 25, 1961	0	Man precursor	Dog Zvez dochka recovered.
Vostok 1	61-Mu 1	Apr. 12, 1961	TT	A-1	4,725	327	181	65.0	[1] 89.1	Apr. 12, 1961	0	First manned flight	Gagarin recovered.

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Vostok 2	61-Tau 1	Aug. 6, 1961	TT	A–1	4,731	257	178	64.9	[1]88.6	Aug. 7, 1961	1	Manned	Titov recovered.
Unstated		Nov. 15, 1961	KY	SS–3	1,500?	430up			(1)	Nov. 15, 1961	0	Geophysical probe	
Kosmos 1	62-Theta 1	Mar. 16, 1962	KY	B–1	315?	980	217	49	[1]96.4	May 25, 1962	70	Geophysics	First Kapustin, Yar orbital launch, particle measurements.
Kosmos 2	62-Iota 1	Apr. 6, 1962	KY	B–1	285?	1,546	212	49	[1]102.3	Aug. 20, 1963	499	Geophysics	Particle and radiation measurements.
Kosmos 3	62-Nu 1	Apr. 24, 1962	KY	B–1	330?	720	229	49	[1]93.8	Oct. 17, 1962	176	Geophysics	Particle and radiation measurements.
Kosmos 4	62-Xi 1	Apr. 26, 1962	TT	A–1	4,600?	330	298	65	[1]90.6	Apr. 29, 1962	3	Military photo	Recovered. First such payload, also biological and meteorological geomagnetic and radiation data.
Kosmos 5	62-Upsilon 1	May 28, 1962	KY	B–1	280?	1,600	203	49.1	[1]102.8	May 2, 1963	339	Geophysics	Particle and radiation measurements.
Kosmos 6	62-Alpha Delta 1	June 30, 1962	KY	B–1	355?	360	274	49	[1]90.6	Aug. 8, 1962	70	Geophysics	Cosmic radiation measurements.
Kosmos 7	62-Alpha Iota 1	July 28, 1962	TT	A–1	4,600?	369	210	65	[1]90.1	Aug. 1, 1962	4	Military photo	Recovered, also biological and meteorological geomagnetic and radiation data.
Vostok 3	62-Alpha Mu 1	Aug. 11, 1962	TT	A–1	4,722	251	183	65	[1]88.5	Aug. 15, 1962	4	Manned	Nikolayev recovered.
Vostok 4	62-Alpha Nu 1	Aug. 12, 1962	TT	A–1	4,728	254	180	65	[1]88.5	Aug. 15, 1962	3	Manned	Popovich recovered. N coorbit at 6.5 km.
Kosmos 8	62-Alpha Xi 1	Aug. 18, 1962	KY	B–1	337?	604	256	49	[1]92.9	Aug. 17, 1963	364	Geophysics	Micrometeorites and atmospheric density.
Venera	62-Alpha Pi 1	Aug. 25, 1962	TT	A–2e	890?	252	173	64.9	[2]88.7	Aug. 28, 1962	3	Venus	Failed to launch toward Venera.
Tyazheliy Sputnik	62-Alpha Pi 1				6,500?	252	173	64.9	[2]88.7	Aug. 28, 1962	3	Intended to launch Venus	
Tyazheliy Sputnik	62-Alpha Tau 1	Sept. 1, 1962	TT	A–2e	6,500?	310	180	64.9	[2]89.4	Sept. 6, 1962	5	Intended to launch Venus	Failed to launch toward Venera.
Venera	62-Alpha Tau 3				890?	310	180	64.9	[2]89.4	Oct. 1, 1962	30	Venus	
Venera	62-Alpha Phi 3	Sept. 12, 1962	TT	A–2e	890?	213	186	64.9	[2]88.5	Sept. 17, 1962	5	Venus	Failed to launch toward Venera.
Tyazheliy Sputnik	62-Alpha Phi 4				6,500?	240	196	64.7	[2]88.7	Sept. 13, 1962	1	Intended to launch Venus	
Kosmos 9	62-Alpha Omega 1	Sept. 27, 1962	TT	A–1	4,600?	358	301	65	[1]90.9	Oct. 1, 1962	4	Military photo	Recovered, also meteorological.
Kosmos 10	62-Beta zeta 1	Oct. 17, 1962	TT	A–1	4,600?	380	210	65	[1]90.2	Oct. 21, 1962	4	Military photo	Recovered.
Unstated		Oct. 18, 1962	KY	SS–3	1,500?	500up			(1)	Oct. 18, 1962	0	Geophysical probe	
Kosmos 11	62-Beta Theta 1	Oct. 20, 1962	KY	B–1	315?	921	245	49	[1]96.1	May 18, 1964	576	Geophysics	Ion and atmospheric density.
Tyazheliy Sputnik	62-Beta Iota 1	Oct. 24, 1962	TT	A–2e	6,500?	485	180	64.9	[2] 91.2	Oct. 29, 1962	5	Intended to launch Mars	
Mars	62-Beta Iota 1				890?	485	180	64.9	[2] 91.2	Oct. 29, 1962	5	Mars	Failed to launch toward Mars.
Tyazheliy Sputnik	62-Beta Nu 2	Nov. 1, 1962	TT	A–2e	6,500?	238	157	65.0	[2] 88.4	Nov. 3. 1962	2	Launched Mars 1	
Mars 1	62-Beta Nu 3				894	1.604au	0.924au	2.68	[2] [5]519			Mars	Passed Mars June 19, 1963, at 193,000 km, but communications failed Mar. 21, 1963.
Mars	62-Beta Xi 3	Nov. 4, 1962	TT	A–2e	890?	590	197	64.7	92.4	Jan. 19, 1963	76	Mars	Failed to launch toward Mars.
Tyzaheliy Sputnik	62-Beta Xi 3				6,500?	590	197	64.7	[2] 92.4	Dec. 25, 1962	51	Intended to launch Mars	
Kosmos 12	62-Beta Omega 1	Dec. 22, 1962	TT	A–1	4,600?	405	211	65	[1] 90.5	Dec. 30, 1962	8	Military photo	Recovered.
Luna	63–1A	Jan. 4, 1963	TT	A–2e	1,420?	196	167	65	[2] 88.5	Jan. 5, 1963	1	Moon	Failed to launch toward Moon.
Tyazheliy Sputnik	63–1A				6,500?	196	167	65	88.5	Jan. 5, 1963	1	Intended to launch Luna	
Kosmos 13	63–6A	Mar. 21, 1963	TT	A–1	4,600?	337	205	65.0	[1] 89.8	Mar. 29, 1963	8	Military photo	Recovered.
Tyazheliy Sputnik	63–8A	Apr. 2, 1963	TT	A–2e	6,500?	297	167	64.7	[2] 88.2	Apr. 3, 1963	1	Launched Luna 4	
Luna 4	63–8B				1,422?	694,000	89,250	65.0	[2] 42,000			Moon	Missed Moon by 8,500 km on Apr. 6, barycentric orbit.
Kosmos 14	63–10A	Apr. 13, 1963	KY	B–1	355?	512	265	49.0	[1] 92.1	Aug. 29, 1963	137	Meteorology	Instrumentation test.
Kosmos 15	63–11A	Apr. 22, 1963	TT	A–1	4,600?	371	173	65.0	[1] 89.8	Apr. 27, 1963	5	Military photo	Recovered, also meteorological.
Kosmos 16	63–12A	Apr. 28, 1963	TT	A–1	4,600?	401	207	65	[1] 90.4	May 8, 1963	10	Military photo	Recovered.
Kosmos 17	63–17A	May 22, 1963	KY	B–1	332?	788	260	49.0	[1] 94.8	June 2, 1965	743	Geophysics	Particle and radiation measurements.
Kosmos 18	63–18A	May 24, 1963	TT	A–1	4,600?	301	209	65	[1] 89.4	June 2, 1963	9	Military photo	Recovered.

Unstated		June 6, 1963	KY	SS-3	1,500?	563up			(1)	June 6, 1963	0	Geophysical probe	
Vostok 5	63-20A	June 14, 1963	TT	A-1	4,720	222	175	65.0	[1] 88.3	June 19, 1963	5	Manned	Bykovskiy recovered.
Vostok 6	63-23A	June 16, 1963	TT	A-1	4,713	233	183	65	[1] 88.3	June 19, 1963	3	First woman in space	Tereshkova recovered, passed within 5 km of Vostok 5.
Unstated		June 18, 1963	KY	SS-3	1,500?	510up			(1)	June 18, 1963	0	Geophysical probe	
Kosmos 19	63-33A	Aug. 6, 1963	KY	B-1	355?	519	270	49	[1] 92.2	Mar. 30, 1964	237	Geophysics	Cosmic radiation and atmospheric density.
Kosmos 20	63-40A	Oct. 18, 1963	TT	A-1	4,600?	311	206	65	[1] 89.6	Oct. 26, 1963	8	Military photo	Recovered.
Unstated		Oct. 25, 1963	KY	SS-3	1,500?	430up				Oct. 25, 1963	0	Geophysical probe	
Polet 1	63-43A	Nov. 1, 1963	TT	A-m	600?	592	339		[1] 94	Nov. 23, 1966	1,087	Maneuver test	Possible test of maneuverable stage used on F vehicle.
						1,437	343	58.9	[1] 102.5				
Kosmos 21	63-44A	Nov. 11, 1963	TT	A-2e	890?	229	195	64.8	[1] 88.5	Nov. 14, 1963	3	Vehicle test	Probable precursor to Venera. Failed to leave Earth orbit.
Tyazheliy Sputnik	63-44A				6,520?	229	195	64.8	[2] 88.5	Nov. 14, 1963	3	Intended to launch Kosmos 21.	
Kosmos 22	63-45A	Nov. 16, 1963	TT	A-2	5,530?	394	205	64.9	[1] 90.3	Nov. 22, 1963	6	Military photo	Recovered, first higher resolution payload.
Kosmos 23	63-50A	Dec. 13, 1963	KY	B-1	347?	613	240	49	[1] 92.9	Mar. 27, 1964	104	Meteorological	Instrumentation test.
Kosmos 24	63-52A	Dec. 19, 1963	TT	A-1	4,600?	408	211	65	[1] 90.5	Dec. 28, 1963	9	Military photo	Recovered.
Unstated		Dec. 24, 1963	KY	SS-3	1,500?	422up				Dec. 24, 1963	0	Geophysical probe	
Elektron 1	64-6A	Jan. 30, 1964	TT	A-1	329	7,100	406	61	[1] 169			Geophysics	May have tested early warning system or nuclear detection as well as scientific instruments.
Elektron 2	64-6B				444	68,200	460	61	[1] 1,360			Geophysics	Launched with Electron 1.
Kosmos 25	64-10A	Feb. 25, 1964	KY	B-1	355?	526	272	49	[1] 92.3	Nov. 21, 1964	267	Geophysics	Cosmic radiation.
Kosmos 26	64-13A	Mar. 18, 1964	KY	B-1	365?	402	271	49	[1] 91	Sept. 28, 1964	194	Geophysics	Magnetic fields.
Kosmos 27	64-14A	Mar. 27, 1964	TT	A-2e	6,520?	237	192	64.9	[1] 88.7	Mar. 28, 1964	1	Intended to launch Venera	
Venera	64-14B				890?	194	181	64.8	[2] 88.2	Mar. 29, 1964	2	Venus	Failed to leave Earth orbit.
Tyazheliy Sputnik	64-16A	Apr. 2, 1964	TT	A-2e	6,520?	213	187	64.8	[2] 88.5	Apr. 3, 1964	1	Launched Zond 1	
Zond 1	64-16D				890?	1.001au	0.652au	3.7	[2,5] 274			Venus	Passed Venus at 100,000 km July 19, 1964, communications failed after May 14, 1964.
Kosmos 28	64-17A	Apr. 4, 1964	TT	A-1	4,600?	395	209	65	[1] 90.4	Apr. 12, 1964	8	Military photo	Recovered.
Poiet 2	64-19B	Apr. 12, 1964	TT	A-m	600?	500	310	58.1	[1] 92.4	June 8, 1966	787	Maneuer test	Possible test of maneuverable stage used on F vehicle.
Kosmos 29	64-21A	Apr. 25, 1964	TT	A-1	4,600?	309	204	65.1	[1] 89.5	May 3, 1964	8	Military photo	Recovered.
Kosmos 30	64-23A	May 18, 1964	TT	A-2	5,530?	383	207	64.9	[1] 90.2	May 26, 1964	8	Military photo	Recovered.
Kosmos 31	64-28A	June 6, 1964	KY	B-1	325?	508	228	49	[1] 91.6	Oct. 20, 1964	136	Radar calibration	First of a large series.
Kosmos 32	64-29A	June 10, 1964	TT	A-1	4,600?	333	209	51.3	[1] 89.8	June 18, 1964	8	Military photo	Recovered.
Kosmos 33	64-33A	June 23, 1964	TT	A-1	4,600?	293	209	65	[1] 89.4	July 1, 1964	8	Military photo	Recovered.
Kosmos 34	64-34A	July 1, 1964	TT	A-2	5,530?	360	205	65.0	[1] 90	July 9, 1964	8	Military photo	Recovered.
Elektron 3	64-38A	July 10, 1964	TT	A-1	350	7040	405	60.9	[1] 168			Geophysics	May have tested early warning system or
Elektron 4	64-38B				444	66,235	459	60.9	[1] 1314			Geophysics	Nuclear detection as well as scientific instruments.
Kosmos 35	64-39A	July 15, 1964	TT	A-1	4,700?	268	217	51.3	[1] 89.2	July 23, 1964	8	Military photo	Recovered.
Kosmos 36	64-42A	July 30, 1964	KY	B-1	325?	503	259	49	[1] 91.9	Feb. 28, 1965	213	Radar calibration	
Kosmos 37	64-44A	Aug. 14, 1964	TT	A-1	4,700?	300	205	65	[1] 89.5	Aug. 22, 1964	8	Military photo	Recovered.
Kosmos 38	64-46A	Aug. 18, 1964	TT	C-1	50?	876	210	56.2	[1] 95.2	Nov. 8, 1964	82	Vehicle test triple launch	Possible precursor to tactical communications satellites. First launch of C vehicle.
Kosmos 39	64-46B				50?	876	210	56.2	[1] 95.2	Nov. 17, 1964	91		
Kosmos 40	64-46C				50?	876	210	56.2	[1] 95.2	Nov. 18, 1964	93		

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Tyazheliy Sputnik	64–49B	Aug. 22, 1964	TT	A–2e	6,000?	471	197	64.7	[2] 91.2	Sept. 28, 1964	37	Vehicle test	Launched Kosmos 41.
Kosmos 41	64–49D				1,500?	39,855	394	64	[1] 71.50			Molniya precursor	Communications precursor.
Kosmos 42	64–50A	Aug. 22, 1964	KY	B–1	100?	1,099	232	49	[1] 97.8	Dec. 19, 1965	484	Vehicle test	Possible precursor to military tactical communications.
Kosmos 43	64–50C				100?	1,099	232	49	[1] 97.8	Dec. 27, 1965	492	Dual launch	
Kosmos 44	64–53A	Aug. 28, 1964	TT	A–1	3,800?	860	618	65	[1] 99.5			Meteorology	First test of a complete system.
Kosmos 45	64–55A	Sept. 13, 1964	TT	A–2	5,530?	327	206	64.9	[1] 89.7	Sept. 18, 1964	5	Military photo	Recovered, also carried out tests of weather instruments.
Kosmos 46	64–59A	Sept. 24, 1964	TT	A–1	4,700?	271	215	51.3	[1] 89.2	Oct. 2, 1964	8	Military photo	Recovered.
Kosmos 47	64–62A	Oct. 6, 1964	TT	A–2	5,320?	413	177	64.8	[1] 90	Oct. 7, 1964	1	Man precursor	Recovered, precursor to Voskhod.
Voskhod 1	64–65A	Oct. 12, 1964	TT	A–2	5,320	409	178	65	[1] 90.1	Oct. 13, 1964	1	Manned	Komarov, Yegorov, Feoktistov recovered.
Kosmos 48	64–66A	Oct. 14, 1964	TT	A–1	4,700?	295	203	65.1	[1] 89.4	Oct. 20, 1964	6	Military photo	Recovered.
Kosmos 49	64–69A	Oct. 24, 1964	KY	B–1	355?	490	260	49	[1] 91.8	Aug. 21, 1965	302	Geophysics	Magnetic fields 1R and UV radiation.
Kosmos 50	64–70A	Oct. 28, 1964	TT	A–1	4,700?	241	196	51.3	[1] 88.7	Nov. 5, 1964	8	Military photo	Exploded before recovery.
Tyazheliy Sputnik	64–78A	Nov. 30, 1964	TT	A–2e	6,530?	219	153	64.7	[2] 88.2	Dec. 1, 1964	1	Launched Zond 2	
Zond 2	64–78C				890?	1.52au	0.98au	6.4	[5] 508			Mars	Passed Mars at 1,500 km Aug. 6, 1965, communications failed earlier.
Kosmos 51	64–80A	Dec. 9, 1964	KY	B–1	350?	554	264	48.8	[1] 92.5	Nov. 14, 1965	340	Geophysics	Luminosity of stellar background.
Kosmos 52	65–1A	Jan. 11, 1965	TT	A–1	4,700?	304	205	65.0	[1] 89.5	Jan. 19, 1965	8	Military photo	Recovered.
Kosmos 53	65–6A	Jan. 30, 1965	KY	B–1	310?	1,192	227	48.8	[1] 98.7	Aug. 12, 1966	559	Geophysics	Cosmic ray and other radiation.
Kosmos 54	65–11A	Feb. 21, 1965	TT	C–1	50?	1,856	280	56.1	[1] 106.2	Sept. 5, 1968	1,302	Vehicle test triple launch	Possible precursor to tactical communication system.
Kosmos 55	65–11B				50?	1,856	280	56.1	[1] 106.2	Feb. 2, 1968	1,076		
Kosmos 56	65–11C				50?	1,856	280	56.1	[1] 106.2	Nov. 2, 1967	985		
Kosmos 57	65–12A	Feb. 22, 1965	TT	A–2	5,682?	512	175	64.8	[1] 91.1	Feb. 22, 1965	0	Man precursor	Probably exploded before recovery, precursor to Voskhod 2.
Kosmos 58	65–14A	Feb. 26, 1965	TT	A–1	3,800?	659	581	65	[1] 96.8			Meteorology	Test of a complete system.
Kosmos 59	65–15A	Mar. 7, 1965	TT	A–2	5,530?	339	209	65	[1] 89.7	Mar. 15, 1965	8	Military photo	Recovered.
Kosmos 60	65–18A	Mar. 12, 1965	TT	A–2e	6,530?	287	201	64.7	[1] 89.1	Mar. 17, 1965	5	Intended to launch Luna	
Luna	65–18A				1,450?	287	201	64.7	[1] 89.1	Mar. 17, 1965	5	Moon	Failed to leave Earth orbit.
Kosmos 61	65–20A	Mar. 15, 1965	TT	C–1	50?	1,837	273	56	[1] 106	Jan. 15, 1968	1,036	Vehicle test triple launch	Possible precursor to tactical communication system, carrier rocket later exploded.
Kosmos 62	65–20B				50?	1,837	273	56	[1] 106	Sept. 24, 1968	1,289		
Kosmos 63	65–20C				50?	1,837	273	56	[1] 106	Nov. 4, 1967	964		
Voskhod 2	65–22A	Mar. 18, 1965	TT	A–2	5,682	495	173	65	[1] 90.9	Mar. 19, 1965	1	Manned	Belyayev, Leonov recovered first EVA.
Kosmos 64	65–25A	Mar. 25, 1965	TT	A–1	4,700?	271	206	65	[1] 89.2	Apr. 2, 1965	8	Military photo	Recovered.
Kosmos 65	65–29A	Apr. 17, 1965	TT	A–2	5,530?	342	210	65	[1] 89.8	Apr. 25, 1965	8	Military photo	Recovered, also had meteorological test.
Molniya 1–1	65–30A	Apr. 23, 1965	TT	A–2e	1,750?	39,380	497	65	[1] 708	May 8, 1979	5,128	Communications	Maneuvered later to stabilized ground trace.
Tyazheliy Sputnik	65–30B				6,000?	801	196	64.8	[2] 94.5	Jul. 20, 1965	88	Launched Molniya	
Kosmos 66	65–35A	May 7, 1965	TT	A–1	4,700?	291	197	65	[1] 89.3	May 15, 1965	8	Military photo	Recovered.
Luna 5	65–36A	May 9, 1965	TT	A–2e	1,476	400,000			(2)	May 12, 1965	3	Moon	Struck Moon at 31S 8W.
Tyazheliy Sputnik	65–36B				6,530?	217	151	64.8	[2] 88.3	May 10, 1965	1	Launched Luna 5	
Kosmos 67	65–40A	May 25, 1965	TT	A–2	5,530?	350	207	51.8	[1] 89.9	June 2, 1965	8	Military photo	Recovered.

Luna 6	65-44A	June 8, 1965	TT	A-2e	1,442							Moon	Passed Moon at 160,000 km June 11, 1965, entered solar orbit.
Tyazheliy Sputnik	65-44B				6,530?	246	167	64.8	[2] 88.7	June 12, 1965	4	Launched Luna 6	
Kosmos 68	65-46A	June 15, 1965	TT	A-1	4,700?	334	205	65	[1] 89.8	June 23, 1965	8	Military photo	Recovered.
Kosmos 69	65-49A	June 25, 1965	TT	A-2	5,530?	332	211	65	[1] 89.7	July 3, 1965	8	Military photo	Recovered, also did meteorology.
Kosmos 70	65-52A	July 2, 1965	KY	B-1	250?	1,154	225	48.8	[1] 98.3	Dec. 18, 1966	535	Radar calibration	
Kosmos 71	65-53A	July 16, 1965	TT	C-1	50?	550	550	56.1	[1] 99.5	Aug. 11, 1970	1,852	Vehicle test quintuple launch	Possible precursor to elint ferret system or tactical communications.
Kosmos 72	65-53B				50?	550	550	56.1	[1] 99.5	Aug. 24, 1979	5,152		
Kosmos 73	65-53C				50?	550	550	56.1	[1] 99.5	Mar. 20, 1974	3,169		
Kosmos 74	65-53D				50?	550	550	56.1	[1] 99.5	Dec. 13, 1979	5,263		
Kosmos 75	65-53E				50?	550	550	56.1	[1] 99.5	Sept. 28, 1979	5,187		
Proton 1	65-54A	July 16, 1965	TT	D-1	12,200	627	190	63.5	[1] 92.5	Oct. 11, 1965	87	Cosmic ray	First launch of D vehicle.
Zond 3	65-56A	July 18, 1965	TT	A-2e	960?	1.56au	0.9au	0.5	[2] [5] 500			System test	Passed Moon at 9,200 km, July 20, 1965, taking pictures, then flew as far as orbital path of Mars.
Tyazheliy Sputnik	65-56B				6,530?	210	164	64.8	[2] 88.2	July 20, 1965	1	Launched Zond 3	
Kosmos 76	65-59A	July 23, 1965	KY	B-1	325?	531	261	48.8	[1] 92.2	Mar. 16, 1966	236	Radar calibration	
Kosmos 77	65-61A	Aug. 3, 1965	TT	A-2	5,530?	291	200	51.8	[1] 89.3	Aug. 11, 1965	8	Military photo	Recovered.
Kosmos 78	65-66A	Aug. 14, 1965	TT	A-1	4,700?	329	206	69	[1] 89.8	Aug. 22, 1965	8	Military photo	Recovered.
Kosmos 79	65-69A	Aug. 25, 1965	TT	A-2	5,530?	359	211	64.9	[1] 90	Sept. 2, 1965	8	Military photo	Recovered.
Kosmos 80-84	65-70A-E	Sept. 3, 1965	TT	C-1	50?	1,500	1,500	56	[1] 116.6			Tactical communications quintuple launch.	1 payload carried RTG nuclear power source.
Kosmos 85	65-71A	Sept. 9, 1965	TT	A-2	5,530?	319	212	65	[1] 89.6	Sept. 17, 1965	8	Military photo	Recovered.
Kosmos 86-90	65-73A-E	Sept. 18, 1965	TT	C-1	50?	1,690	1,380	56	[1] 116.7			Tactical communications quintuple launch.	1 payload carried RTG nuclear power source.
Unstated		Sept. 20, 1965	KY	SS-3		480up				Sept. 20, 1965	0	Geophysical probe	Ionospheric, solar UV, and X-ray.
Kosmos 91	65-75A	Sept. 23, 1965	TT	A-2	5,530?	342	212	65	[1] 89.8	Oct. 1, 1965	8	Military photo	Recovered.
Unstated		Oct. 1, 1965	KY	SS-3		500up				Oct 1, 1965	0	Geophysical probe	Ionospheric, solar UV, and X-ray.
Luna 7	65-77A	Oct. 4, 1965	TT	A-2e	1,506	400,000			(2)	Oct. 7, 1965	3	Moon	Struck Moon at 9N 40W.
Tyazheliy Sputnik	65-77C				6,530?	272	124	64.8	[2] 88.4	Oct 5, 1965	1	Launched Luna 7	
Molniya 1-2	65-80A	Oct. 14, 1965	TT	A-2e	1,750?	40,000	500	65	[1] 719	Mar. 17, 1967	518	Communications	
Tyazheliy Sputnik	65-80D				6,000?	424	198	64.8	[2] 91.2	Nov. 16, 1965	24	Launched Molniya	
Kosmos 92	65-83A	Oct. 16, 1965	TT	A-2	5,530?	353	212	65	[1] 89.9	Oct. 24, 1965	8	Military photo	Recovered, also meteorological and biological tests.
Kosmos 93	65-84A	Oct. 19, 1965	KY	B-1	305?	522	220	48.4	[1] 91.7	Jan. 3, 1966	76	Radar calibration	
Unstated	65-84E				50?	435	370	48.4	[2] 92.6	July 6, 1968	626		Possible pickaback test.
Kosmos 94	65-85A	Oct. 28, 1965	TT	A-2	5,530?	293	211	65	[1] 89.3	Nov. 5, 1965	8	Military photo	Probably recovered, also biological experiments.
Proton 2	65-87A	Nov. 2, 1965	TT	D-1	12,200	637	191	63.5	[1] 92.6	Feb. 6, 1966	96	Cosmic ray	
Kosmos 95	65-88A	Nov. 4, 1965	KY	B-1	325?	521	207	48.4	[1] 91.7	Jan. 18, 1966	75	Radar calibration	
Venera 2	65-91A	Nov. 12, 1965	TT	A-2e	963	1.197au	0.716au	4.29	[2] [5] 341	Feb. 27, 1966		Venus	Passed Venus at 24,000 km, Feb. 27, 1966, communications failed.
Tyazheliy Sputnik	65-91				6,540?	216	203	51.9	[2] 88.7	Nov. 17, 1965	5	Launched Venera 2	

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Venera 3	65-92A	Nov. 16, 1965	TT	A-2e	960	1.11au	0.7au	4.29	[2] [5] 316	Mar. 1, 1965	105	Venus	Struck Venus 0656 Mar. 1, 1966, communications failed earlier.
Tyazheliy Sputnik	65-92				6,540?	293	213	51.9	[2] 89.5	Nov. 26, 1965	10	Launched Venera 3.	
Kosmos 96	65-94A	Nov. 23, 1965	TT	A-2e	6,540?	310	227	51.9	[1] 89.6	Dec. 9, 1965	16	Intended to launch Venera	
Venera	65-94				960?							Venus	Failed to launch to Venus.
Kosmos 97	65-95A	Nov. 26, 1965	KY	B-1	267?	2,100	220	49	[1] 108.3	Apr. 2, 1967	492	Atomic and maser clock	
Kosmos 98	65-97A	Nov. 27, 1965	TT	A-1	4,575?	570	216	65	[1] 92	Dec. 5, 1965	8	Military photo	Recovered, first high apogee orbit.
Luna 8	65-99A	Dec. 3, 1965	TT	A-2e	1,552	400,000			([2])	Dec. 6 1965	3	Moon	Struck Moon 9.1N 63.3W.
Tyazheliy Sputnik	65-99				6,540?	209	169	51.8	[2] 88.2	Dec. 6, 1965	2	Launched Luna 8.	
Kosmos 99	65-103A	Dec. 10, 1965	TT	A-1	4,700?	320	199	65	[1] 89.6	Dec. 18, 1965	8	Military photo	Recovered.
Kosmos 100	65-106A	Dec. 17, 1965	TT	A-1	3,800?	650	650	65	[1] 97.7			Meteorology	Test of complete system.
Kosmos 101	65-107A	Dec. 21, 1965	KY	B-1	325?	550	260	49	[1] 92.4	July 12, 1966	203	Radar calibration	
Kosmos 102	65-111A	Dec. 27, 1965	TT	A-1m	4,700?	278	218	65	[1] 89.2	Jan. 13, 1966	17	Vehicle test	Possible test of stage for F vehicle.
Kosmos 103	65-112A	Dec. 28, 1965	TT	C-1	875?	600	600	56	[1] 97			Vehicle test	Possible store-dump or elint ferret test.
Kosmos 104	66-1A	Jan. 7, 1966	TT	A-1	4,700?	401	204	65	[1] 90.2	Jan. 15, 1966	8	Military photo	Recovered.
Kosmos 105	66-3A	Jan. 22, 1966	TT	A-1	4,700?	324	204	65	[1] 89.7	Jan. 30, 1966	8	Military photo	Recovered.
Kosmos 106	66-4A	Jan. 25, 1966	KY	B-1	325?	564	270	48.4	[1] 92.8	Nov. 14, 1966	293	Radar calibration	
Luna 9	66-6A	Jan. 31, 1966	TT	A-2e	1,583	400,000			([2])	Feb. 3, 1966	3	Moon	Soft landed on Moon at 7.1N 64.3W, returned pictures.
Tyazheliy Sputnik	66-6B				6,540?	219	167	51.9	[2] 88.3	Feb. 2, 1966	2	Launched Luna 9	
Kosmos 107	66-10A	Feb. 10, 1966	TT	A-1	4,700?	322	204	65	[1] 89.7	Feb. 18, 1966	8	Military photo	Recovered.
Kosmos 108	66-11A	Feb. 11, 1966	KY	B-1	355?	865	227	48.9	[1] 93.5	Nov. 21, 1966	283	Geophysics	Upper atomosphere and solar activity.
Kosmos 109	66-14A	Feb. 19, 1966	TT	A-2	5,530?	309	209	65	[1] 89.5	Feb. 27, 1966	8	Military photo	Recovered, also biological tests.
Kosmos 110	66-15A	Feb. 22, 1966	TT	A-2	5,700	904	187	51.9	[1] 96.3	Mar. 16, 1966	22	Biological	Dogs Veterok, Ugolek recovered.
Kosmos 111	66-17A	Mar. 1, 1966	TT	A-2e	6,540?	226	191	51.9	[1] 88.6	Mar. 3, 1966	2	Intended to launch Luna	
Luna					1,600?	226	191	51.9	[1] 88.6	Mar. 3, 1966	2	Moon	Failed to leave Earth orbit.
Kosmos 112	66-21A	Mar. 17, 1966	PL	A-1	4,575?	565	214	72	[1] 92.1	Mar. 25, 1966	8	Military photo	Recovered, first Plesetsk launch high apogee orbit.
Kosmos 113	66-23A	Mar. 21, 1966	TT	A-2	5,530?	327	210	65	[1] 89.6	Mar. 29, 1966	8	Military photo	Recovered.
Luna 10	66-27A	Mar. 31, 1966	TT	A-2e	1,600	1,017	350	71.9	[1] 178.3			Moon	Lunar orbit, Apr. 3, 1966.
Tyazheliy Sputnik	66-27B				6,540?	250	200	52	[2] 88.5	Apr. 4, 1966	4	Launched Luna 10	
Kosmos 114	66-28A	Apr. 6, 1966	PL	A-2	5,530?	374	210	73	[1] 90.1	Apr. 14, 1966	8	Military photo	Recovered.
Kosmos 115	66-33A	Apr. 20, 1966	TT	A-1	4,700?	204	190	65	[1] 89.3	Apr. 28, 1966	8	Military photo	Recovered.
Molniya 1-3	66-35A	Apr. 25, 1966	TT	A-2e	1,750?	39,500	499	64.5	[1] 710	Jun. 11, 1973	2,604	Communications	
Tyazheliy Sputnik	66-35B				6,000?	449	176	64.9	[2] 90.8	May 9, 1966	14	Launched Molniya.	
Kosmos 116	66-36A	Apr. 26, 1966	KY	B-1	325?	478	294	48.4	[1] 92	Dec. 3, 1966	221	Radar calibration	
Kosmos 117	66-37A	May 6, 1966	TT	A-1	4,700?	308	207	65	[1] 89.5	May 14, 1966	8	Military photo	Recovered.
Kosmos 118	66-38A	May 11, 1966	TT	A-1	3,800?	640	640	65	[1] 97.1			Meteorology	Developmental.
Kosmos 119	66-43A	May 24, 1966	KY	B-1	250?	1,305	219	48.5	[1] 99.8	Nov. 30, 1966	190	Radar calibration	
Kosmos 120	66-50A	June 8, 1966	TT	A-2	5,530?	300	200	51.8	[1] 89.4	June 16, 1966	8	Military photo	Recovered, first improved medium resolution.
Kosmos 121	66-54A	June 17, 1966	PL	A-2	5,530?	354	210	72.9	[1] 89.9	Jun. 25, 1966	8	Military photo	Recovered.
Kosmos 122	66-57A	Jun. 25, 1966	TT	A-1	3,800?	625	625	65	[1] 97.1			Meteorology	Developmental, early operational supplemental IR studies.
Proton 3	66-60A	July 6, 1966	TT	D-1	12,200	630	190	63.5	[1] 92.5	Sept 16, 1966	72	Cosmic rays	
Kosmos 123	66-61A	July 8, 1966	KY	B-1	325?	529	263	48.8	[1] 92.2	Dec. 10, 1966	156	Radar calibration	
Kosmos 124	66-64A	July 14, 1966	TT	A-2	5,530?	303	208	51.8	[1] 89.4	July 22, 1966	8	Military photo	Recovered.

Kosmos 125	66-67A	July 21, 1966	TT	A-1m	4,000?	250	250	65	[1] 89.5	Aug. 2, 1966	13	Vehicle test	Possible test of stage for F vehicle. Ion orientation test.
Kosmos 126	66-68A	July 28, 1966	TT	A-2	5,530?	359	212	51.8	[1] 90.0	Aug. 6, 1966	9	Military photo	Recovered.
Kosmos 127	66-71A	Aug. 8, 1966	TT	A-2	5,530?	279	204	51.9	[1] 89.2	Aug. 16, 1966	8	Military photo	Recovered.
Luna 11	66-78A	Aug. 24, 1966	TT	A-2e	1,640	1,200	160	27	[1] 178			Moon	Lunar orbit, Aug. 29, 1966.
Tyazheliy Sputnik	66-78				6,540?	190	177	51.9	[2] 88.1	Aug. 2, 1966	1	Launched Luna 11	
Kosmos 128	66-79A	Aug. 27, 1966	TT	A-2	5,530?	364	212	65	[1] 90.0	Sept. 4, 1966	8	Military photo	Recovered.
Kosmos	66-88A	Sept. 17, 1966	TT	F-1r	4,250?	1,046	163	49.6	[2] 96.1	Nov. 11, 1966	54	Possible FOBS related	Probably failed, first launch of F vehicle into orbit.
Yantar 1		Oct. 13, 1966	KY	SS-3?	1,300?	400up				Oct. 13, 1966	0	Ion propulsion probe	Also ionospheric studies.
Kosmos 129	66-91A	Oct. 14, 1966	PL	A-1	4,700?	307	202	65	[1] 89.4	Oct. 21, 1966	7	Military photo	Recovered.
Molniya 1-4	66-92A	Oct. 20, 1966	TT	A-2e	1,750?	39,400	485	64.9	[1] 71.3	Sept. 11, 1968	692	Communications	
Tyazheliy Sputnik	66-92B				6,000?	443	189	64.8	[2] 90.8	Nov. 10, 1966	21	Launched Molniya	
Kosmos 130	66-93A	Oct. 20, 1966	TT	A-2	5,530?	340	211	65	[1] 89.8	Oct. 28, 1966	8	Military photo	Recovered.
Luna 12	66-94A	Oct. 22, 1966	TT	A-2e	1,620	1,740	100	~0.0?	[1] 205			Moon	Lunar orbit Oct. 25, 1966.
Tyazheliy Sputnik	66-94B				6,540?	212	199	51.9	[2] 88.6	Oct. 24, 1966	2	Launched Luna 12	
Kosmos	66-101A	Nov. 2, 1966	TT	F-1r	4,400?	855	140	49.6	[2] 94.5	Nov. 17, 1966	15	Possible FOBS related	Probably failed.
Kosmos 131	66-105A	Nov. 12, 1966	PL	A-2	5,530?	360	205	72.9	[1] 89.9	Nov. 20, 1966	8	Military photo	Recovered.
Kosmos 132	66-106A	Nov. 19, 1966	TT	A-1	4,700?	280	207	65	[1] 89.3	Nov. 27, 1966	8	Military photo	Recovered.
Kosmos 133	66-107A	Nov. 28, 1966	TT	A-2	6,450?	232	181	51.8	[1] 88.4	Nov. 30, 1966	2	Man precursor	First Soyuz precursor, recovered.
Kosmos 134	66-108A	Dec. 3, 1966	TT	A-2	5,530?	319	214	65	[1] 89.6	Dec. 11, 1966	8	Military photo	Recovered, proton electron radiation counters.
Kosmos 135	66-112A	Dec. 12, 1966	KY	B-1	355?	662	259	48.5	[1] 93.5	Apr. 12, 1967	121	Geophysics	Micrometeorites and gamma radiation.
Kosmos 136	66-115A	Dec. 19, 1966—	PL	A-1	4,700?	305	198	64.6	[1] 89.4	Dec. 27, 1966	8	Military photo	Recovered, also scientific experiment and proton electron radiation counters.
Luna 13	66-116A	Dec. 21, 1966	TT	A-2e	1,700?	400,000			(1)	Dec. 24, 1966	3	Moon	Soft landed on Moon at 18.9N 62W, returned pictures.
Tyazheliy Sputnik	66-116B				6,540?	223	171	51.8	[2] 88.4	Dec. 23, 1966	2	Launched Luna 13	
Kosmos 137	66-117A	Dec. 21, 1966	KY	B-1	295?	1,720	230	48.8	[1] 104.3	Nov. 23, 1967	337	Geophysics	Radiation and particle studies.
Kosmos 138	67-4A	Jan 19, 1967	PL	A-1	4,700?	293	191	65	[1] 89.2	Jan. 27, 1967	8	Military photo	Recovered.
Kosmos 139	67-5A	Jan. 25, 1967	TT	F-1r	5,000?	210	144	50	[1] 87.5	Jan. 25, 1967	0	FOBS	
Kosmos 140	67-9A	Feb. 7, 1967	TT	A-2	6,450?	241	170	51.7	[1] 88.5	Feb. 9, 1967	2	Man precursor	Soyuz test, recovered.
Kosmos 141	67-12A	Feb. 8, 1967	PL	A-2	5,530?	345	210	72.9	[1] 89.8	Feb. 16, 1967	8	Military photo	Recovered.
Kosmos 142	67-13A	Feb. 14, 1967	KY	B-1	315?	1,362	214	48.4	[1] 100.3	July 6, 1967	142	Geophysics	Radio propagation.
Kosmos 143	67-17A	Feb. 27, 1967	TT	A-1	4,700?	302	204	65	[1] 89.5	Mar. 7, 1967	8	Military photo	Recovered, also charged particle experiments.
Kosmos 144	67-18A	Feb. 28, 1967	PL	A-1	3,800?	625	625	81.2	[1] 96.9			Meteorology	Early operational.
Kosmos 145	67-19A	Mar. 3, 1967	KY	B-1	250?	2,135	220	48.4	[1] 108.6	Mar. 8, 1968	371	Radar calibration	
Kosmos 146	67-21	Mar. 10, 1967	TT	D-1e	5,375?	310	190	51.5	[1] 89.1	Mar. 18, 1967	8	Possible Zond test	Ambiguous man precursor, separated after 1 day, part disappeared.
Tyazheliy Sputnik	67-21A				18,000?	310	190	51.5	[2] 89.1	Mar. 11, 1967	1	Intended to launch Kosmos 146.	
Kosmos 147	67-22A	Mar. 13, 1967	PL	A-1	4,700	317	198	65	[1] 89.5	Mar. 21, 1967	8	Military photo	Recovered.
Kosmos 148	67-23A	Mar. 16, 1967	PL	B-1	325?	436	275	71.0	[1] 91.3	May 7, 1967	52	Radar calibration	
Kosmos 149	67-24A	Mar. 21, 1967	KY	B-1	375?	297	248	48.4	[1] 89.8	Apr. 7, 1967	17	Meteorology	Experimental, aerodynamic stabilization.
Kosmos 150	67-25A	Mar. 22, 1967	PL	A-2	5,530?	373	206	65.7	[1] 90.1	Mar. 30, 1967	8	Military photo	Recovered.
Kosmos 151	67-27A	Mar. 24, 1967	TT	C-1	875?	630	630	56	[1] 97.1			Vehicle test	Possible store-dump or elint ferret test.
Kosmos 152	67-28A	Mar. 25, 1967	PL	B-1	325?	512	283	71.0	[1] 92.2	Aug. 5, 1967	133	Radar calibration	
Kosmos 153	67-30A	Apr. 4, 1967	PL	A-1	4,700?	291	202	64.6	[1] 89.3	Apr. 12, 1967	8	Military photo	Recovered.
Kosmos 154	67-32A	Apr. 8, 1967	TT	D-1e	5,375?	232	186	51.6	[1] 88.5	Apr. 10, 1967	2	Possible Zond Test	Ambiguous man precursor.

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Tyazheliy Sputnik	67-32A				18,000?	232	186	51.6	[2] 88.5	Apr. 10, 1967	2	Intended to launch Kosmos 154.	
Kosmos 155	67-33A	Apr. 12, 1967	TT	A-2	5,530?	286	203	51.8	[1] 89.2	Apr. 20, 1967	8	Military photo	Recovered.
Soyuz 1	67-37A	Apr. 23, 1967	TT	A-2	6,450	224	201	51.7	[1] 88.6	Apr. 24, 1967	1	Manned	Komarov killed on landing.
Kosmos 156	67-39A	Apr. 27, 1967	PL	A-1	3,800?	630	630	81.2	[1] 97			Meteorology	Early operational.
Kosmos 157	67-44A	May 12, 1967	TT	A-1	4,700?	296	202	51.3	[1] 89.4	May 20, 1967	8	Military photo	Recovered.
Kosmos 158	67-45A	May 15, 1967	PL	C-1	750?	850	850	74.0	[1] 100.6			Developmental	Possible store-dump test.
Kosmos 159	67-46A	May 17, 1967	TT	A-2e	4,490?	60,600	380	51.8	[1] 1177	Nov. 11, 1977	3,832	Possible Zond test	Ambiguous man precursor.
Tyazheliy Sputnik	67-46C				6,540?	395	208	51.7	[2] 90.5	June 2, 1967	17	Launched Kosmos 159	
Kosmos 160	67-47A	May 17, 1967	TT	F-1r	5,000?	205	142	49.6	[1] 87.8	May 18, 1967	1	FOBS	
Kosmos 161	67-49A	May 22, 1967	PL	A-2	5,530?	343	205	65.7	[1] 89.8	May 30, 1967	8	Military photo	Recovered.
Molniya 1-5	67-52A	May 24, 1967	TT	A-2e	1,750?	39,810	460	64.0	[1] 715	Nov. 26, 1971	1,647	Communications	
Tyazheliy Sputnik	67-52C				6,000?	472	203	64.9	[2] 91.3	June 15, 1967	22	Launched Molniya	
Kosmos 162	67-54A	June 1, 1967	TT	A-2	5,530?	280	201	51.8	[1] 89.2	June 9, 1967	8	Military photo	Recovered.
Kosmos 163	67-56A	June 5, 1967	KY	B-1	357?	616	261	48.4	[1] 93.1	Oct. 11, 1967	128	Cosmic ray telescope	
Kosmos 164	67-57A	June 8, 1967	PL	A-2	5,530?	320	202	65.7	[1] 89.5	June 14, 1967	6	Military photo	Recovered.
Venera 4	67-58A	June 12, 1967	TT	A-2e	1,106	1.11au	0.7au	.4	[2] [5] 316	Oct. 18, 1967	128	Venus	Probed atmosphere.
Tyazheliy Sputnik	67-58B				6,540?	188	162	51.8	[2] 87.9	June 13, 1967	2	Launched Venera 4	
Kosmos 165	67-59A	June 12, 1967	PL	B-1	250?	1,542	211	81.9	[1] 102.1	Jan. 15, 1968	217	Radar calibration	
Kosmos 166	67-61A	June 16, 1967	KY	B-1	357?	578	283	48.4	[1] 92.9	Oct. 25, 1967	131	Geophysics	Orbiting solar observatory.
Kosmos 167	67-63A	June 17, 1967	TT	A-2e	1,106?	286	201	51.8	[1] 89.2	June 25, 1967	8	Venus	Failed to leave Earth orbit.
Tyazheliy Sputnik	67-63B				6,540?	266	187	51.8	[2] 89.0	June 21, 1967	5	Intended to launch Venera	
Kosmos 168	67-67A	July 4, 1967	TT	A-2	5,530?	268	199	51.8	[1] 89.1	July 12, 1967	8	Military photo	Recovered.
Kosmos 169	67-69A	July 17, 1967	TT	F-1r	5,000?	208	144	50	[1] 87.6	July 17, 1967	0	FOBS	
Kosmos 170	67-74A	July 31, 1967	TT	F-1r	5,000?	208	145	50	[1] 87.9	July 31, 1967	0	FOBS	
Kosmos 171	67-77A	Aug. 8, 1967	TT	F-1r	5,000?	220	145	50	[1] 87.6	Aug. 8, 1967	0	FOBS	
Kosmos 172	67-78A	Aug. 9, 1967	TT	A-2	5,530?	301	202	51.8	[1] 89.4	Aug. 17, 1967	8	Military photo	Recovered.
Kosmos 173	67-81A	Aug. 24, 1967	PL	B-1	325?	528	280	71	[1] 92.3	Dec. 17, 1967	115	Radar calibration	
Kosmos 174	67-82A	Aug. 31, 1967	TT	A-2e	1,750?	39,750	500	64.5	[1] 715.0	Dec. 30, 1967	487	Early warning	
Tyazheliy Sputnik	67-82B				6,000?	454	199	64.8	91.1	Sept. 19, 1967	19	Launched Kosmos 174	
Kosmos 175	67-85A	Sept. 11, 1967	PL	A-2	5,530?	386	210	72.9	[1] 90.2	Sept. 19, 1967	8	Military photo	Recovered.
Kosmos 176	67-86A	Sept. 12, 1967	PL	B-1	250?	1,581	206	81.9	[1] 102.5	Sept. 3, 1968	357	Radar calibration	Rocket exploded.
Kosmos 177	67-88A	Sept. 16, 1967	TT	A-2	5,530?	292	202	51.8	[1] 89.3	Sept. 24, 1967	8	Military photo	Recovered.
Kosmos 178	67-89A	Sept. 19, 1967	TT	F-1r	5,000?	205	145	50.0	[1] 87.8	Sept. 19, 1967	0	FOBS	
Kosmos 179	67-91A	Sept. 22, 1967	TT	F-1r	5,000?	208	145	50.0	[1] 87.9	Sept. 22, 1967	0	FOBS	
Kosmos 180	67-93A	Sept. 26, 1967	PL	A-2	5,530?	370	212	72.9	[1] 90.1	Oct. 4, 1967	8	Military photo	Recovered.
Molniya 1-6	67-95A	Oct. 3, 1967	TT	A-2e	1,750?	39,600	465	65.0	[1] 712.0	Mar. 4, 1969	519	Communications	
Tyazheliy Sputnik	67-95B				6,000?	441	200	64.8	[2] 91.0	Oct. 17, 1967	18	Launched Molniya	
Kosmos 181	67-97A	Oct. 11, 1967	PL	A-2	5,530?	344	200	65.6	[1] 89.7	Oct. 19, 1967	8	Military photo	Recovered.
Unstated		Oct. 12, 1967	TT	C	500?	11,104up			(1)	Oct. 12, 1967	0	Geophysical probe	Solar and ionospheric measures.
Kosmos 182	67-98A	Oct. 16, 1967	TT	A-2	5,530?	355	210	65.0	[1] 89.9	Oct. 24, 1967	8	Military photo	Recovered.
Kosmos 183	67-99A	Oct. 18, 1967	TT	F-1r	5,000?	212	145	50.0	[1] 87.9	Oct. 18, 1967	0	FOBS	
Molniya 1-7	67-101A	Oct. 22, 1967	TT	A-2e	1,750?	39,740	456	64.7	[1] 714.0	Dec. 31, 1969	801	Communications	
Tyazheliy Sputnik	67-101B				6,000?	443	202	64.8	[2] 91.0	Nov. 7, 1967	16	Launched Molniya	
Kosmos 184	67-102A	Oct. 24, 1967	PL	A-1	3,800?	635	635	81.2	[1] 97.1			Meteorology	Operational: ion orientation, also ionosphere plasma.
Kosmos 185	67-104A	Oct. 27, 1967	TT	F-1m	4,000?	546	370	64.1	[2] 93.6	Jan. 14, 1969	445	Vehicle test	Possible precursor to antisatellite (ASAT).
						888	522	64.1	[1] 98.7				

Kosmos 186	67-105A	Oct. 27, 1967	TT	A-2	6,530?	235	209	51.7	[1] 88.7	Oct. 31, 1967	4	Man preccursor	Soyuz precursor docked with Kosmos 188, recovered.
Kosmos 187	67-106A	Oct. 28, 1967	TT	F-1r	5,000?	210	145	50.0	[1] 87.8	Oct. 28, 1967	0	FOBS	
Kosmos 188	67-107A	Oct. 30, 1967	TT	A-2	6,530?	276	200	51.7	[1] 89.0	Nov. 2, 1967	3	Man precursor	Soyuz precursor docked with Kosmos 186, recovered.
Kosmos 189	67-108A	Oct. 30, 1967	PL	C-1	875?	600	535	74.0	[1] 95.7	June 8, 1978	3,874	Elint ferret	
Kosmos 190	67-110A	Nov. 3, 1967	PL	A-2	5,530?	347	201	65.7	[1] 89.8	Nov. 11, 1967	8	Military photo	Recovered.
Kosmos 191	67-115A	Nov. 21, 1967	PL	B-1	325?	518	281	71.0	[1] 92.2	Mar. 2, 1968	102	Radar calibration	
Kosmos 192	67-116A	Nov. 23, 1967	PL	C-1	775?	760	760	74.0	[1] 99.9			Navigation	Experimental.
Kosmos 193	67-117A	Nov. 25, 1967	PL	A-2	5,530?	354	203	65.7	[1] 89.9	Dec. 3, 1967	8	Military photo	Recovered.
Kosmos 194	67-119A	Dec. 3, 1967	PL	A-2	5,530?	333	205	65.7	[1] 89.7	Dec. 11, 1967	8	Military photo	Recovered.
Kosmos 195	67-124A	Dec. 16, 1967	PL	A-2	5,530?	375	211	65.7	[1] 90.1	Dec. 24, 1967	8	Military photo	Recovered.
Kosmos 196	67-125A	Dec. 19, 1967	KY	B-1	352?	887	225	49	[1] 95.5	July 7, 1968	203	Geophysics	Upper atmosphere research.
Kosmos 197	67-126A	Dec. 26, 1967	KY	B-1	325?	505	220	48.5	[1] 91.5	Jan. 30, 1968	35	Radar calibration	
Kosmos 198	67-127A	Dec. 27, 1967	TT	F-1m	4,540?	281	265	65.1	[1] 89.8			Ocean surveillance vehicle test.	Portion maneuvered up to higher orbit Dec. 29, 1967.
						952	894	65.2	[2] 103.4				
Kosmos 199	68-3A	Jan. 16, 1968	PL	A-2	5,530?	386	204	65.7	[1] 90.2	Feb. 1, 1968	16	Military photo	Recovery failed, exploded.
Kosmos 200	68-6A	Jan. 19, 1968	PL	C-1	875?	536	536	74	[1] 95.2	Feb. 24, 1973	1,863	Elint ferret	
Kosmos 201	68-9A	Feb. 6, 1968	TT	A-2	5,530?	355	210	65	[1] 89.9	Feb. 14, 1968	8	Military photo	Recovered.
Kosmos 202	68-10A	Feb. 20, 1968	KY	B-1	325?	502	220	48.4	[1] 91.5	Mar. 24, 1968	32	Radar calibration	
Kosmos 203	68-11A	Feb. 20, 1968	PL	C-1	600?	1,200	1,200	74.1	[1] 109.4			Geodetic	Or navigation.
Zond 4	68-13A	Mar. 2, 1968	TT	D-1e	5,375?	400,000			(2)	Mar. 9, 1968	7	Man precursor	Launched in direction away from Moon in test flight, probably returned to Earth.
Tyazheliy Sputnik	68-13B				18,000?	206	190	51.5	[2] 88.4	Mar. 7, 1968	5	Launched Zond 4	
Kosmos 204	68-15A	Mar. 5, 1968	PL	B-1	300?	873	282	71	[1] 95.9	Mar. 2, 1969	362	Radar calibration	
Kosmos 205	68-16A	Mar. 5, 1968	PL	A-2	5,530?	310	201	65.7	[1] 89.4	Mar. 13, 1968	8	Military photo	Recovered.
Kosmos 206	68-19A	Mar. 14, 1968	PL	A-1	3,800?	630	630	81	[1] 97			Meteorology	Operational.
Kosmos 207	68-21A	Mar. 16, 1968	PL	A-2	5,530?	342	210	65.6	[1] 89.8	Mar. 24, 1968	8	Military photo	Recovered.
Kosmos 208	68-22A	Mar. 21, 1968	TT	A-2	5,900?	305	207	65	[1] 89.4	Apr. 2, 1968	12	Military photo	Recovered, first-third generation pay load low resolution, PDM format.
Pickaback	68-22C				200?	264	196	65.0	[2] 89.1	Apr. 6, 1968	16	Geophysics	Gamma flux and X-ray.
Kosmos 209	68-23A	Mar. 22, 1968	TT	F-1m	4,540?	282	250	65.1	[1] 89.6			Ocean surveillance vehicle test.	Portion manuvered up to higher orbit, Mar. 28, 1968.
						944	871	65.3	[2] 103.1				
Kosmos 210	68-24A	Apr. 3, 1968	PL	A-2	5,530?	395	217	81.2	[1] 90.3	Apr. 11, 1968	8	Military photo	Recovered.
Luna 14	68-27A	Apr. 7, 1968	TT	A-2e	1,700?	870	160	42	[1] 160			Moon	Lunar orbit, Apr. 10, 1968.
Tyazheliy Sputnik	68-27B				6,500?	242	189	51.8	[2] 88.8	Apr. 9, 1968	2	Launched Luna 14	
Kosmos 211	68-28A	Apr. 9, 1968	PL	B-1	250?	1,574	210	81.9	[1] 102.5	Nov. 10, 1968	215	Radar calibration	
Kosmos 212	68-29A	Apr. 14, 1968	TT	A-2	6,530?	239	210	51.7	[1] 88.8	Apr. 19, 1968	5	Man precursor	Soyuz precursor docked with Kosmos 213.
Kosmos 213	68-30A	Apr. 15, 1968	TT	A-2	6,530?	291	205	51.4	[1] 89.2	Apr. 20, 1968	5	Man precursor	Soyuz precursor docked with Kosmos 212.
Kosmos 214	68-32A	Apr. 18, 1968	PL	A-2	5,530?	403	211	81.4	[1] 90.3	Apr. 26, 1968	8	Military photo	Recovered.
Kosmos 215	68-33A	Apr. 18, 1968	KY	B-1	385?	426	261	48.5	[1] 91.1	June 30, 1968	73	Astronomy	Multitelescope observatory.
Kosmos 216	68-34A	Apr. 20, 1968	TT	A-2	5,530?	277	199	51.8	[1] 89.1	Apr. 28, 1968	8	Military photo	Recovered.
Molniya 1-8	68-35A	Apr. 21, 1968	TT	A-2e	1,750?	39,700	460	65	[1] 7130	Jan. 29, 1974	2.109	Communications	
Tyazheliy Sputnik	68-35				6,000?	460	244	64.9	[2] 91.5	May 11, 1968	38	Launched Molniya	
Kosmos 217	68-36A	Apr. 24, 1968	TT	F-1m	4,000?	262	144	62.2	[2] 88.5	Apr. 26, 1968	2	ASAT precursor	Apparently never reached the orbit announced by Tass.
						520	396	62.2	[1] 93.4				
Kosmos 218	68-37A	Apr. 25, 1968	TT	F-1r	5,000?	210	144	50	[1] 87.8	Apr. 25, 1968	0	FOBS	
Kosmos 219	68-38A	Apr. 26, 1968	KY	B-1	300?	1,770	222	48.4	[1] 104.7	Mar. 2, 1969	310	Geophysics	Charged particle studies.
Kosmos 220	68-40A	May 7, 1968	PL	C-1	775?	760	670	74	[1] 99.2			Navigation	Experimental.
Kosmos 221	68-43A	May 24, 1968	KY	B-1	250?	2,108	220	48.4	[1] 108.4	Aug. 31, 1969	464	Radar calibration	

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 222	68-44A	May 30, 1968	PL	B-1	325?	528	277	71	[1] 92.3	Oct. 11, 1968	134	Radar calibration	
Kosmos 223	68-45A	June 1, 1968	PL	A-2	5,530?	374	212	72.9	[1] 90.1	June 9, 1968	8	Military photo	Recovered.
Kosmos 224	68-46A	June 4, 1968	TT	A-2	5,530?	270	200	51.8	[1] 89	June 12, 1968	8	Military photo	Recovered, also atmospheric composition luminescence.
Kosmos 225	68-48A	June 11, 1968	KY	B-1	375?	530	257	48.4	[1] 92.2	Nov. 2, 1968	144	Geophysics	Electron flux, cosmic rays.
Kosmos 226	68-49A	June 12, 1968	PL	A-1	3,800?	650	603	81.2	[1] 96.9			Meteorology	Operational.
Kosmos 227	68-51A	June 18, 1968	TT	A-2	5,530?	281	194	51.8	[1] 89.1	June 26, 1968	8	Military photo	Recovered.
Kosmos 228	68-53A	June 21, 1968	TT	A-2	5,900?	259	206	51.6	[1] 89	July 3, 1968	12	Military photo	Recovered.
Pickaback	68-53G				200?	153	153	51.6	[2] 87.5	July 7, 1968	16	Geophysics	Cosmic ray, ionizing radiation.
Kosmos 229	68-54A	June 26, 1968	PL	A-2	5,530?	354	210	72.8	[1] 88.9	July 4, 1968	8	Military photo	Recovered.
Kosmos 230	68-56A	July 5, 1968	KY	B-1	367?	580	290	48.5	[1] 93	Nov. 2, 1968	121	Solar physics	Orbiting solar observatory.
Molniya 1-9	68-57A	July 6, 1968	TT	A-2e	1,750?	39,770	470	65	[1] 715	May 15, 1971	1,044	Communications	
Tyazheliy Sputnik	68-57C				6,000?	472	243	65	[2] 91.7	Aug. 22, 1968	47	Launched Molniya	
Kosmos 231	68-58A	July 10, 1968	TT	A-2	5,530?	330	211	65	[1] 89.7	July 18, 1968	8	Military photo	Recovered.
Kosmos 232	68-60A	July 16, 1968	PL	A-2	5,530?	352	202	65	[1] 89.8	July 24, 1968	8	Military photo	Recovered passive microwave for meteorology.
Kosmos 233	68-61A	July 18, 1968	PL	B-1	250?	1,545	210	82	[1] 102.1	Feb. 7, 1969	203	Radar calibration	
Kosmos 234	68-62A	July 30, 1968	TT	A-2	5,530?	310	210	51.8	[1] 89.5	Aug. 5, 1968	6	Military photo	Recovered.
Kosmos 235	68-67A	Aug. 9, 1968	TT	A-2	5,530?	303	207	51.8	[1] 89.4	Aug. 17, 1968	8	Military photo	Recovered.
Kosmos 236	68-70A	Aug. 27, 1968	TT	C-1	875?	655	600	56	[1] 96.9			Developmental	Possible store-dump or elint ferret test.
Kosmos 237	68-71A	Aug. 27, 1968	PL	A-2	5,530?	343	201	65.4	[1] 89.7	Sept. 4, 1968	8	Military photo	Recovered.
Kosmos 238	68-72A	Aug. 28, 1968	TT	A-2	6,520?	219	199	51.7	[1] 88.5	Sept. 1, 1968	4	Man precursor	Soyuz test, recovered.
Kosmos 239	68-73A	Sept. 5, 1968	TT	A-2	5,530?	282	202	51.8	[1] 89.2	Sept. 13, 1968	8	Military photo	Recovered.
Kosmos 240	68-75A	Seot. 14, 1968	TT	A-2	5,530?	293	197	51.8	[1] 89.3	Sept. 21, 1968	7	Military photo	Recovered.
Zond 5	68-76A	Sept. 14, 1968	TT	D-1e	5,375?	400,000			(2)	Sept. 21, 1968	7	Man precursor	Circumlunar, recovered. Landed Indian Ocean.
Tyazheliy Sputnik	68-76B				18,000?	219	187	51.3	[2] 88.4	Sept. 16, 1968	1	Launched Zond 5	
Kosmos 241	68-77A	Sept. 16, 1968	PL	A-2	5,530?	343	201	65.4	[1] 89.7	Sept. 24, 1968	8	Military photo	Recovered.
Kosmos 242	68-79A	Sept. 20, 1968	PL	B-1	325?	440	280	71	[1] 91.3	Nov. 13, 1968	54	Radar calibration	
Kosmos 243	68-80A	Sept. 23, 1968	TT	A-2	5,900?	319	210	71.3	[1] 89.6	Oct. 4, 1968	11	Military photo	Recovered.
Pickaback	68-80C				200?	284	203	71.3	[2] 89.4	Oct. 12, 1968	19	Geophysics	Passive microwave radio telescope.
Kosmos 244	68-82A	Oct. 2,1968	TT	F-1r	5,000?	212	140	50	[1] 87.3	Oct. 2, 1968	0	FOBS	
Kosmos 245	68-83A	Oct. 3, 1968	PL	B-1	325?	509	282	71	[1] 92.1	Jan. 15, 1969	104	Radar calibration	
Molniya 1-10	68-85A	Oct. 5, 1968	TT	A-2e	1,750?	39,600	490	65	[1] 712	Jul. 16, 1976	2841	Communications	
Tyazheliy Sputnik	68-85C				6,000?	466	224	65.0	[2] 91.4	Nov. 4, 1968	31	Launched Molniya	
Kosmos 246	68-87A	Oct. 7, 1968	PL	A-2	5,530?	348	147	65.4	[1] 89.4	Oct. 12, 1968	5	Military photo	Recovered.
Kosmos 247	68-88A	Oct. 11, 1968	PL	A-2	5,530?	362	205	65.4	[1] 89.9	Oct. 19, 1968	8	Military photo	Recovered.
Kosmos 248	68-90A	Oct. 19, 1968	TT	F-1m	4,000?	551	490	62.3	[1] 94.8	Feb. 26, 1980	4,147	Target for ASAT	
Kosmos 249	68-91A	Oct. 20, 1968	TT	F-1m	3,320?	2,177	514	62.4	[1] 112.2			ASAT	Passed near Kosmos 248, exploded.
Soyuz 2	68-93A	Oct. 25, 1968	TT	A-2	6,520?	224	185	51.7	[1] 88.5	Oct. 28, 1968	3	Unmanned	Target for rendezvous of Soyuz 3, but no docking.
Soyuz 3	68-94A	Oct. 26, 1968	TT	A-2	6,575?	203	177	51.7	[2] 88.3	Oct. 30, 1968	4	Manned	Beregovoy recovered, approached Soyuz 2.
						225	205	51.7	[1] 88.6				
						241	196	51.7	[2] 88.9				
Kosmos 250	68-95A	Oct. 30, 1968	PL	C-1	875?	556	523	74	[1] 95.3	Feb. 15, 1978	3,395	Elint Ferret	
Kosmos 251	68-96A	Oct. 31, 1968	TT	A-2	6,300?	270	198	65	[1] 89.1	Nov. 12, 1968	12	Military photo	Also radio astronomy, gamma rays recovered. First maneuverable third generation high resolution.

Kosmos 252	68–97A	Nov. 1, 1968	TT	F–1m	3,320?	2,172	538	61.9	[1] 112.5			ASAT	Passed year Kosmos 248, exploded.
Zond 6	68–101A	Nov. 10, 1968	TT	D–1e	5,375?	400,000			(2)	Nov. 17, 1968	7	Man precursor	Circumlunar, 2,420 km from Moon, Nov. 14. Landed U.S.S.R.
Tyazheliy Sputnik	68–101B				180,000?	210	185	51.4	[2] 87.9	Nov. 12, 1968	1	Launched Zond 6	
Kosmos 253	68–102A	Nov. 13, 1968	PL	A–2	5,630?	355	206	65.4	[1] 89.9	Nov. 18, 1968	5	Military photo	Recovered.
Proton 4	68–103A	Nov. 16, 1968	TT	D–1	17,000	495	255	51.5	[1] 91.8	July 24, 1969	250	Cosmic rays	
Kosmos 254	68–104A	Nov. 21, 1968	PL	A–2	5,530?	350	203	65.4	[1] 89.8	Nov. 29, 1968	8	Military photo	Recovered.
Kosmos 255	68–105A	Nov. 29, 1968	PL	A–2	5,530?	336	201	65.4	[1] 89.7	Dec. 7, 1968	8	Military photo	Recovered.
Kosmos 256	68–106A	Nov. 30, 1968	PL	C–1	600?	1,234	1,168	74.1	[1] 109.3			Geodetic	
Kosmos 257	68–107A	Dec. 3, 1968	PL	B–1	325?	470	282	71	[1] 91.1	Mar. 5, 1969	92	Radar calibration	
Kosmos 258	68–111A	Dec. 10, 1968	TT	A–2	5,530?	325	210	65	[1] 89.6	Dec. 18, 1968	8	Military photo	Recovered.
Kosmos 259	68–113A	Dec. 14, 1968	KY	B–1	325?	1,353	219	48.5	[1] 100.3	May 5, 1969	142	Geophysics	Ionosphere studies, radio propagation.
Kosmos 260	68–115A	Dec. 16, 1968	TT	A–2e	1,750?	39,600	500	65	[1] 712	July 9, 1973	1,666	Early warning	
Tyazheliy Sputnik	68–115B				6,000?	510	240	64.9	[2] 92.0	Jan. 18, 1969	33	Launched Kosmos 260	
Kosmos 261	68–117A	Dec. 19, 1968	PL	B–1	347?	670	217	71	[1] 93.1	Feb. 12, 1969	54	Geophysics	Corpuscular streams, upper atmosphere and polar.
Kosmos 262	68–119A	Dec. 26, 1968	KY	B–1	352?	818	263	48.5	[1] 95.2	July 18, 1969	204	Geophysics	Hard radiation intensity.
Venera 5	69–1A	Jan. 5, 1969	TT	A–2e	1,130	1.08au	0.72au	2	[2] [5] 313	May 16, 1969	131	Venus	Entered Venus atmosphere, May 16, 1969.
Tyazheliy Sputnik	69–1C				6,540?	225	186	51.8	[2] 88.6	Jan. 7, 1969	2	Launched Venera 5	
Venera 6	69–2A	Jan. 10, 1969	TT	A–2e	1,130	1.08au	0.72au	2	[2] 313	May 17, 1969	127	Venus	Entered Venus atmosphere May 17, 1969.
Tyazheliy Sputnik	69–2C				6,540?	207	201	51.7	[2] 88.5	Jan. 13, 1969	3	Launched Venera 6	
Kosmos 263	69–3A	Jan. 12, 1969	PL	A–2	5,530?	346	205	65.4	[1] 89.8	Jan. 20, 1969	8	Military photo	Recovered.
Soyuz 4	69–4A	Jan. 14, 1969	TT	A–2	6,625	225	173	51.7	[1] 88.3	Jan. 17, 1969	3	Manned	Shatalov joined by Yeliseyev and Khrunov after docking, used EVA, recovered.
						223	205	51.7	[2] 88.7				
Soyuz 5	69–5A	Jan. 15, 1969	TT	A–2	6,585	230	200	51.7	[1] 88.7	Jan. 18, 1969	3	Manned	Volynov, Yeliseyev, and Khrunov EVA, recovered.
Kosmos 264	69–8A	Jan. 23, 1969	TT	A–2	6,300?	330	219	70	[1] 89.7	Feb. 5, 1969	13	Military photo	Extra galactic radio sources recovered.
Kosmos 265	69–12A	Feb. 7, 1969	PL	B–1	325?	485	283	71	[1] 91.9	May 1, 1969	83	Radar calibration	
Kosmos 266	69–15A	Feb. 25, 1969	PL	A–2	5,530?	358	208	72.9	[1] 89.9	Mar. 5, 1969	8	Military photo	Recovered.
Kosmos 267	69–17A	Feb. 26, 1969	TT	A–2	5,530?	346	210	65	[1] 89.9	Mar. 6, 1969	8	Military photo	Recovered.
Kosmos 268	69–20A	Mar. 5, 1969	KY	B–1	250?	2,186	219	48.4	[1] 109.2	May 9, 1970	430	Radar calibration	
Kosmos 269	69–21A	Mar. 5, 1969	PL	C–1	875?	558	526	74	[1] 95.3	Oct. 21, 1978	3,517	Elint ferret	
Kosmos 270	69–22A	Mar. 6, 1969	PL	A–2	5,530?	350	205	65.4	[1] 89.8	Mar. 14, 1969	8	Military photo	Recovered.
Kosmos 271	69–23A	Mar. 15, 1969	PL	A–2	5,530?	342	200	65.4	[1] 89.7	Mar. 23, 1969	8	Military photo	Recovered.
Kosmos 272	69–24A	Mar. 17, 1969	PL	C–1	600?	1,220	1,195	74	[1] 109.4			Geodetic	
Kosmos 273	69–27A	Mar. 22, 1969	PL	A–2	5,530?	356	205	65.4	[1] 89.9	Mar. 30, 1969	8	Military photo	Recovered.
Kosmos 274	69–28A	Mar. 24, 1969	TT	A–2	5,530?	323	213	65	[1] 89.6	Apr. 1, 1969	8	Military photo	Recovered, neutral and ionized atmospheric composition experiment.
Meteor 1–1	69–29A	Mar. 27, 1969	PL	A–1	3,800?	713	644	81.2	[1] 97.9			Meteorology	
Kosmos 275	69–31A	Mar. 28, 1969	PL	B–1	300?	805	284	71	[1] 95.2	Feb. 7, 1970	316	Radar calibration	
Kosmos 276	69–32A	Apr. 4, 1969	PL	A–2	5,530?	410	214	81.4	[1] 90.4	Apr. 11, 1969	7	Military photo	Recovered.
Kosmos 277	69–33A	Apr. 4, 1969	PL	B–1	325?	494	280	71	[1] 92	July 6, 1969	93	Radar calibration	
Kosmos 278	69–34A	Apr. 9, 1969	PL	A–2	5,530?	338	203	65	[1] 89.7	Apr. 17, 1969	8	Military photo	Recovered.
Molniya 1–11	69–35A	Apr. 11, 1969	TT	A–2e	1,750?	39,700	470	65	[1] 713	Apr. 17, 1974	1,832	Communications	
Tyazheliy Sputnik	69–35D				6,000?	461	222	65.0	91.4	May 5, 1969	24	Launched Molniya	
Kosmos 279	69–38A	Apr. 15, 1969	TT	A–2	5,530?	280	194	51.8	[1] 89.1	Apr. 23, 1969	8	Military photo	Recovered., ion orientation test.
Kosmos 280	69–40A	Apr. 23, 1969	TT	A–2	6,300?	272	206	51.6	[1] 89.1	May 6, 1969	13	Military photo	Recovered, weather studies also, and charged particles.
Kosmos 281	69–42A	May 13, 1969	PL	A–2	5,530?	317	194	65.4	[1] 89.4	May 21, 1969	8	Military photo	Recovered.

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 282	69-44A	May 20, 1969	PL	A-2	5,530?	343	209	65.4	[1]89.8	May 28, 1969	8	Military photo	Recovered.
Kosmos 283	69-47A	May 27, 1969	PL	B-1	250?	1,539	210	82	[1]102.1	Dec. 10, 1969	197	Radar calibration	
Kosmos 284	69-48A		TT	A-2	5,530?	308	207	51.8	[1]89.5	June 6, 1969	8	Military photo	Recovered.
Kosmos 285	69-49A	June 3, 1969	PL	B-1	325?	518	279	71	[1]92.2	Oct. 7, 1969	126	Radar calibration	
Kosmos 286	69-52A	June 15, 1969	PL	A-2	5,530?	349	206	65.4	[1]89.8	June 23, 1969	8	Military photo	Recovered.
Kosmos 287	69-54A	June 24, 1969	TT	A-2	5,530?	268	190	51.8	[1]89	July 2, 1969	8	Military photo	Recovered.
Kosmos 288	69-55A	June 27, 1969	TT	A-2	5,530?	281	201	51.8	[1]89.2	July 5, 1969	8	Military photo	Recovered.
Kosmos 289	69-57A	July 10, 1969	PL	A-2	5,530?	350	200	65.4	[1]89.8	July 15, 1969	5	Military photo	Recovered.
Luna 15	69-58A	July 13, 1969	TT	D-1e	5,600?	870	240	126	[2]160	July 21, 1969	8	Moon	Lunar orbit, then crashed in soft landing attempt.
						110	16	127	[2]114				
Tyazheliy Sputnik	69-58B				18,000?	247	182	51.6	[2]88.7	July 16, 1969	4	Launched Luna 15	
Kosmos 290	69-60A	July 22, 1969	PL	A-2	5,530?	352	200	65.4	[1]89.8	July 30, 1969	8	Military photo	Recovered.
Molniya 1-12	69-61A	July 22, 1969	TT	A-2e	1,750?	39,540	520	64.9	[1]711	July 18, 1971	696	Communications	
Tyazheliy Sputnik	69-61B				6,000?	492	228	64.9	[2]91.7	Aug. 23, 1969	32	Launched Molniya	
Kosmos 291	69-66A	Aug. 6, 1969	TT	F-1m	4,000?	574	153	62.3	[1]91.5	Sept. 8, 1969	34	ASAT vehicle test	Probably failed.
Zond 7	69-67A	Aug. 7, 1969	TT	D-1e	5,375?	400,000			(2)	Aug. 14, 1969	7	Man precursor	Circumlunar, 2,200 km from Moon, Aug. 11. Landed U.S.S.R.
Tyazheliy Sputnik	69-67B				18,000?	191	183	51.5	[2]88.2	Aug. 10, 1969	2	Launched Zond 7	
Kosmos 292	69-70A	Aug. 13, 1969	PL	C-1	775?	786	747	74	[1]99.9			Navigation	Experimental.
Kosmos 293	69-71A	Aug. 16, 1969	TT	A-2	5,900?	270	208	51.8	[1]89.1	Aug. 28, 1969	12	Military photo	Recovered.
Pickaback	69-71A				200	270	208	51.8	[2]89.1	Aug. 28, 1969	12		Failed to separate.
Kosmos 294	69-72A	Aug. 19, 1969	PI	A-2	5,530?	348	202	65.4	[1]89.8	Aug. 27, 1969	8	Military photo	Recovered.
Kosmos 295	69-73A	Aug. 22, 1969	PL	B-1	325?	500	282	71	[1]92	Dec. 1, 1969	101	Radar calibration	
Kosmos 296	69-75A	Aug. 29, 1969	TT	A-2	5,530?	322	211	65	[1]89.6	Sept. 6, 1969	8	Military photo	Recovered.
Kosmos 297	69-76A	Sept. 2, 1969	PL	A-2	5,530?	334	211	72.9	[1]89.7	Sept. 10, 1969	8	Military photo	Recovered.
Kosmos 298	69-77A	Sept. 15, 1969	TT	F-1r	5,000?	212	140	50	[1]87.3	Sept. 15, 1969	0	FUBS	
Kosmos 299	69-78A	Sept. 18, 1969	TT	A-2	5,530?	311	214	65	[1]89.5	Sept. 22, 1969	4	Military photo	Recovered.
Kosmos 300	69-80A	Sept. 23, 1969	TT	D-1e	5,600?	208	190	51.5	[1]88.2	Sept. 27, 1969	4	Moon	Failed to leave Earth orbit.
Tyazheliy Sputnik	69-80A				18,000?	208	190	51.5	[2]88.2	Sept. 27, 1969	4	Intended to launch Kosmos 300.	
Kosmos 301	69-81A	Sept. 24, 1969	PL	A-2	5,530?	307	197	65.4	[1]89.4	Oct. 2, 1969	8	Military photo	Recovered.
Meteor 1-2	69-84A	Oct. 6, 1969	PL	A-1	3,800?	690	630	81.2	[1]97.7			Meteorology	
Soyuz 6	69-85A	Oct. 11, 1969	TT	A-2	6,577	223	186	51.7	88.4	Oct. 16, 1969	5	Manned	Shonin, Kubasov, recovered welding tests, rendezvous with Soyuz 7.
Soyuz 7	69-86A	Oct. 12, 1969	TT	A-2	6,570	230	194	51.7	[1]88.6	Oct. 17, 1969	5	Manned	Filipichenko, Gorbatko, Volkov, recovered.
Soyuz 8	69-87A	Oct. 13, 1969	TT	A-2	6,646	223	205	51.7	[1]88.6	Oct. 18, 1969	5	Manned	Shatalov, Yeliseyev, recovered, failed to dock with Soyuz 7.
Interkosmos 1	69-88A	Oct. 14, 1969	KY	B-1	320?	640	260	48.4	[1]93.3	Jan. 2, 1970	80	Geophysics	Solar UV and X-ray, upper atmosphere measures.
Kosmos 302	69-89A	Oct. 17, 1969	PL	A-2	5,530?	340	202	65.4	[1]89.7	Oct. 25, 1969	8	Military photo	Recovered.
Kosmos 303	69-90A	Oct. 18, 1969	PL	B-1	325?	492	282	71	[1]91.9	Jan. 23, 1970	97	Radar calibration	
Kosmos 304	69-91A	Oct. 21, 1969	PL	C-1	795?	774	747	74	[1]99.9			Navigation	Experimental.
Kosmos 305	69-92A	Oct. 22, 1969	TT	D-1e	5,600?	205	193	51.5	[1]88.2	Oct. 24, 1969	2	Moon	Failed to leave Earth orbit.
Tyazheliy Sputnik	69-92B				18,000?	203	171	51.5	[2]88.2	Oct. 24, 1969	2	Intended to launch Kosmos 305.	Debris in orbit.
Kosmos 306	69-93A	Oct. 24, 1969	TT	A-2	5,700?	332	208	65	[1]89.7	Nov. 5, 1969	12	Military photo	Recovered.
Kosmos 307	69-94A	Oct. 24, 1969	KY	B-1	250?	2,178	220	48.4	[1]109.1	Dec. 30, 1970	432	Radar calibration	
Kosmos 308	69-96A	Nov. 4, 1969	PL	B-1	325?	422	282	71	[1]91.3	Jan. 5, 1970	61	Radar calibration	

Kosmos 309	69-98A	Nov. 12, 1969	PL	A-2	5,900?	384	203	65.4	[1] 90.1	Nov. 20, 1969	8	Military photo	Recovered, possible repeat of Kosmos 208.
Pickaback	69-98E				200?	~380	~200	~65.4	~90.0	Nov. 30, 1969	18		
Kosmos 310	69-100A	Nov. 15, 1969	TT	A-2	5,530?	347	208	65	[1] 89.8	Nov. 23, 1969	8	Military photo	Recovered.
Kosmos 311	69-102A	Nov. 24, 1969	PL	B-1	325?	496	284	71	[1] 92	Mar. 10, 1970	106	Radar calibration	
Kosmos 312	69-103A	Nov. 24, 1969	PL	C-1	600?	1,187	1,145	74	[1] 108.6			Geodetic	
Kosmos 313	69-104A	Dec. 3, 1969	PL	A-2	5,700?	276	204	65.4	[1] 89.1	Dec. 15, 1969	12	Military photo	Recovered.
Kosmos 314	69-106A	Dec. 11, 1969	PL	B-1	325?	491	282	71	[1] 91.9	Mar. 22, 1970	101	Radar calibration	
Kosmos 315	69-107A	Dec. 20, 1969	PL	C-1	875?	556	521	74	[1] 95.3	Mar. 25, 1979	3,382	Elint ferret	
Kosmos 316	69-108A	Dec. 23, 1969	TT	F-1r	3,640?	1,,650	154	49.5	[1] 102.7	Aug. 28, 1970	248	Possible FOBS related	May have failed.
Kosmos 317	69-109A	Dec. 23, 1969	PL	A-2	6,300?	302	209	65.4	[1] 89.4	Jan. 5, 1970	13	Military photo	Recovered charged particle studies, first 2-tone, 3d gen. maneuverable satellite.
Interkosmos 2	69-110A	Dec. 25, 1969	KY	B-1	320?	1,200	206	48.4	[1] 98.5	Jun. 7, 1970	165	Geophysics	Night ionosphere, magnetosphere. Ions and electrons concentration.
Kosmos 318	70-1A	Jan. 9, 1970	TT	A-2	5,700?	295	204	65	[1] 89.3	Jan. 21, 1970	12	Military photo	Recovered.
Kosmos 319	70-4A	Jan. 15, 1970	PL	B-1	250?	1,539	209	82	[1] 102	July 1, 1970	167	Radar calibration	
Kosmos 320	70-5A	Jan. 16, 1970	KY	B-1	375?	342	240	48.5	[1] 90	Feb. 10, 1970	25	Meteorological	Aerodynamic stabilization with annular ring.
Kosmos 321	70-6A	Jan. 20, 1970	PL	B-1	365?	507	289	71	[1] 92	Mar. 23, 1970	61	Geophysics	Geomagnetic and ionosphere.
Kosmos 322	70-7A	Jan 21, 1970	PL	A-2	5,530?	337	200	65.4	[1] 89.7	Jan. 29, 1970	8	Military photo	Recovered.
Kosmos 323	70-10A	Feb. 10, 1970	PL	A-2	5,530?	333	206	65.4	[1] 89.7	Feb. 18, 1970	8	Military photo	Recovered.
Molniya 1-13	70-13A	Feb. 19, 1970	PL	A-2e	1,750?	39,175	487	65.3	[1] 703	Sept. 29, 1975	2,048	Communications	First use of A-2e at Plesetsk.
Tyazheliy Sputnik	70-13B				6,000?	485	205	65.4	[2] 91.4	Mar. 9, 1970	17	Launched Molniya	
Kosmos 324	70-14A	Feb. 27, 1970	PL	B-1	325?	492	283	71	[1] 92	May 23, 1970	85	Radar calibration	
Kosmos 325	70-15A	Mar. 4, 1970	PL	A-2	5,530?	348	207	65.4	[1] 89.8	Mar. 12 1970	8	Military photo	Recovered.
Kosmos 326	70-18A	Mar. 13, 1970	PL	A-2	5,530?	393	212	81.4	[1] 90.2	Mar. 21, 1970	8	Military photo	Recovered.
Meteor 1-3	70-19A	Mar. 17, 1970	PL	A-1	3,800?	643	555	81.2	[1] 96.4			Meteorology	
Kosmos 327	70-20A	Mar. 18, 1970	PL	B-1	300?	855	279	71	[1] 95.6	Jan. 19, 1971	306	Radar calibration	
Kosmos 328	70-22A	Mar. 27, 1970	PL	A-2	6,300?	340	213	72.9	[1] 89.7	Apr. 9, 1970	13	Military photo	Recovered.
Kosmos 329	70-23A	Apr. 3, 1970	PL	A-2	5,700?	240	202	81.3	[1] 88.8	Apr. 15 1970	12	Military photo	Recovered.
Kosmos 330	70-24A	Apr. 7, 1970	PL	C-1	875?	548	514	74.1	[1] 95.2	Jun. 12, 1979	3,353	Elint ferret	
Kosmos 331	70-26A	Apr. 8, 1970	TT	A-2	5,530?	347	213	65	[1] 89.9	Apr. 16, 1970	8	Military photo	Recovered.
Kosmos 332	70-28A	Apr. 11. 1970	PL	C-1	775?	786	775	74.5	[1] 100			Navigation	Experimental.
Kosmos 333	70-30A	Apr. 15, 1970	PL	A-2	6,300?	265	217	81.4	[1] 89.1	Apr. 28, 1970	13	Military photo	Recovered.
Kosmos 334	70-33A	Apr. 23, 1970	PL	B-1	325?	508	281	71	[1] 92.1	Aug. 9, 1970	108	Radar calibration	
Kosmos 335	70-35A	Apr. 24, 1970	KY	B-1	395?	415	254	48.7	[1] 91	Jun. 6, 1970	23	Geophysics	Ultraviolet studies.
Kosmos 336-343	70-36A-H	Apr. 25, 1970	PL	C-1	50?	1,500	1,400	74	[1] 115			Tactical communications octuple launch.	
Meteor 1-4	70-37A	Apr. 28, 1970	PL	A-1	3,800?	736	637	81.2	[1] 98.1			Meteorology	
Kosmos 344	70-38A	May 12, 1970	PL	A-2	5,530?	347	206	72.9	[1] 89.8	May 20, 1970	8	Military photo	Recovered.
Kosmos 345	70-39A	May 20, 1970	TT	A-2	5,530?	276	193	51.8	[1] 89.1	May 28, 1970	8	Military photo	Recovered.
Soyuz 9	70-41A	June 1, 1970	TT	A-2	6,500	220	207	51.7	[1] 88.6	June 19, 1970	18	Manned	Nikolayev, Sevastyanov, recovered
						266	247	51.7	[2] 89.5				
Kosmos 346	70-42A	June 10, 1970	TT	A-2	5,530?	289	201	51.8	[1] 89.3	July 17, 1970	7	Military photo	Recovered.
Kosmos 347	70-43A	June 12, 1970	KY	B-1	250?	2,073	223	48.4	[1] 108	Nov. 7, 1971	513	Radar calibration	

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 348	70–44A	June 13, 1970	PL	B–1	357?	680	212	71	[1]93	July 25, 1970	42	Geophysics	Corpuscular streams, Interkosmos program.
Kosmos 349	70–45A	June 17, 1970	PL	A–2	5,530?	350	203	65.4	[1]89.8	June 25, 1970	8	Military photo	Recovered.
Meteor 1–5	70–47A	June 23, 1970	PL	A–1	3,300?	906	863	81.2	[1]102			Meteorology	
Molniya 1–14	70–49A	June 26, 1970	PL	A–2e	1750?	39,280	470	65	[1]705	Feb. 16, 1976	2,061	Communications	
Tyazheliy Sputnik	70–49B				6,000?	462	225	65.4	91.4	July 25, 1970	30	Launched Molniya	
Kosmos 350	70–50A	June 26, 1970	TT	A–2	5,700?	267	204	51.8	[1]89.1	July 8, 1970	12	Military photo	Recovered.
Kosmos 351	70–51A	June 27, 1970	PL	B–1	325?	494	282	71	[1]92	Oct. 13, 1970	108	Radar calibration	
Kosmos 352	70–52A	July 7, 1970	TT	A–2	5,530?	309	205	51.8	[1]89.5	July 15, 1970	8	Military photo	Recovered.
Kosmos 353	70–53A	July 9, 1970	PL	A–2	5,700?	309	211	65.4	[1]89.4	July 21, 1970	12	Military photo	Recovered.
Kosmos 354	70–56A	July 28, 1970	TT	F–1r	5,000?	208	144	50	[1]87.5	July 28, 1970	0	FOBS	
Interkosmos 3	70–57A	Aug. 7, 1970	KY	B–1	340	1,320	207	49	[1]99.8	Dec. 6, 1970	121	Geophysics	Cosmic rays and changed particles.
Kosmos 355	70–58A	Aug. 7, 1970	PL	A–2	5,530?	342	202	65.4	[1]89.7	Aug. 15, 1970	8	Military photo	Recovered.
Kosmos 356	70–59A	Aug. 10, 1970	PL	B–1	357?	600	240	82	[1]92.6	Oct. 2, 1970	53	Geophysics	Atmospheric count ionospheric studies.
Venera 7	70–60A	Aug. 17, 1970	TT	A–2e	1,180	1.08au	0.72au	2	[2,5]313	Dec. 15, 1970	120	Venus	Soft landed on Venus, signal from surface.
Tyazheliy Sputnik	70–60B				6,540?	233	174	51.7	[2]88.5	Aug. 18, 1970	2	Launched Venera 7	
Kosmos 357	70–63A	Aug. 19, 1970	PL	B–1	325?	500	282	71	[1]92	Nov. 24, 1970	97	Radar calibration	
Kosmos 358	70–64A	Aug. 20, 1970	PL	C–1	875?	549	517	74	[1]95.2			Elint ferret	
Kosmos 359	70–65A	Aug. 22, 1970	TT	A–2e	1,180?	910	210	51.5	[1]95.5	Nov. 6, 1970	76	Venus	Failed to leave Earth orbit.
Tyazheliy Sputnik	70–65C				6,540?	890	207	51.2	[2]95.6	Sept. 11, 1970	20	Intended to launch Kosmos 359.	
Kosmos 360	70–68A	Aug. 29, 1970	TT	A–2	6,300?	318	209	65	[1]89.5	Sept. 8, 1970	10	Military photo	Recovered.
Kosmos 361	70–71A	Sept. 8, 1970	PL	A–2	6,300?	326	207	72.9	[1]89.6	Sept. 21, 1970	13	Military photo	Recovered.
Luna 16	70–72A	Sept. 12, 1970	TT	D–1e	5,600?	110	110	70	[2]119	Sept. 20, 1970	8	Moon	Automated return of soil sample to Earth.
						106	15	71	[2]114				
Tyazheliy Sputnik	70–72B				18,000	241	185	51.5	[2]88.7	Sept. 15, 1970	3	Launched Luna 16	
Sample returner	70–72E	Sept. 21, 1970	Moon		470?					Sept. 24, 1970	3	Carry lunar soil	Recovered in U.S.S.R.
Kosmos 362	70–73A	Sept. 16, 1970	PL	B–1	300?	854	281	71	[1]95.7	Oct. 13, 1971	392	Radar calibration	
Kosmos 363	70–74A	Sept. 17, 1970	TT	A–2	5,700?	324	210	65	[1]89.6	Sept. 29, 1970	12	Military photo	Recovered.
Kosmos 364	70–75A	Sept. 22, 1970	PL	A–2	6,300?	330	211	65.4	[1]89.6	Oct. 2, 1970	10	Military photo	Recovered.
Kosmos 365	70–76A	Sept. 25, 1970	TT	F–1r	5,000?	210	144	49.5	[1]87.5	Sept. 25, 1970	0	FOBS	
Molniya 1–15	70–77A	Sept. 29, 1970	PL	A–2e	1,750?	39,300	480	65.5	[1]706	Mar. 20, 1976	1,999	Communications	
Tyazheliy Sputnik	70–77B				6,000?	469	228	65.4	[2]91.5	Oct. 23, 1970	24	Launched Molniya	
Kosmos 366	70–78A	Oct. 1, 1970	TT	A–2	5,700?	310	206	65	[1]89.5	Oct. 13, 1970	12	Military photo	Recovered.
Kosmos 367	70–79A	Oct. 3, 1970	TT	F–1m	4,540?	280	250	65.5	[2]89.6			Ocean surveillance	Maneuvered Oct. 3, 1970 almost immediately.
						1,030	932	65.3	[1]104.5				
Unstated		Oct. 3, 1970	KY	SS–3	1,300?	500 up				Oct. 3, 1970	0	Geophysical probe	Solar UV and X-ray.
Kosmos 368	70–80A	Oct. 8, 1970	TT	A–2	5,900?	421	212	65	[1]90.6	Oct. 14, 1970	6	Military photo	Recovered.
Pickaback	70–80E				200?	243	178	64.9	[2]88.7	Nov. 4, 1970	27		Biological and radiation experiment.
Kosmos 369	70–81A	Oct. 8, 1970	PL	B–1	325?	534	278	71	[1]92.3	Jan. 22, 1971	106	Radar calibration	
Kosmos 370	70–82A	Oct. 9, 1970	TT	A–2	6,300?	307	208	65	[1]89.5	Oct. 22, 1970	13	Military photo	Recovered.
Kosmos 371	70–83A	Oct. 12, 1970	PL	C–1	775?	780	754	74	[1]99.9			Navigation	Experimental.
Interkosmos 4	70–84A	Oct. 14, 1970	KY	B–1	320?	668	263	48.5	[1]93.6	Jan. 7, 1971	95	Geophysics	
Meteor 1–6	70–85A	Oct. 15, 1970	PL	A–1	3,800?	674	633	81.2	[1]97.5			Meteorology	
Kosmos 372	70–86A	Oct. 16, 1970	PL	C–1	750?	828	786	74	[1]100.8			Store-dump communications	
Kosmos 373	70–87A	Oct. 20, 1970	TT	F–1m	3,320?	1,102	510	62.8	[2]100.9	Mar. 8, 1980	3,427	Target for ASAT	
						553	490	62.9	[1]94.8				

Zond 8	70-88A	Oct. 20, 1970	TT	D-1e	5,375?	400,000			(2)	Oct. 27, 1970	7	Man precursor	Circumlunar, passed 1,120 km of Moon Oct. 24, landed in Indian Ocean.
Tyazheliy Sputnik	70-88B				18,000	223	202	51.5	[2] 88.7	Oct. 26, 1970	6	Launched Zond 8	
Kosmos 374	70-89A	Oct. 23, 1970	TT	F-1m	3,320?	1,053	530	62.9	[2] 100.6			ASAT	Approached Kosmos 373, but exploded later.
						2,153	536	63	[1] 112.3				
Kosmos 375	70-91A	Oct. 30, 1970	TT	F-1m	3,320?	1,000	500	62.8	[2] 100			ASAT	Approached Kosmos 373, exploded thereafter.
						2,164	538	63	[1] 112.4				
Kosmos 376	70-92A	Oct. 30, 1970	PL	A-2	6,300?	311	216	65.4	[1] 89.5	Nov. 12, 1970	13	Military photo	Recovered.
Luna 17	70-95A	Nov. 10, 1970	TT	D-1e	5,600	85	85	141	[2] 116	Nov. 17, 1970	7	Moon	Landed Lunokhod roving surface vehicle 756 kg, after orbiting Moon.
						85	19	141	[2] 114				
Tyazheliy Sputnik	70-95C				18,000	237	192	51.6	[2] 88.7	Nov. 13, 1970	3	Launched Luna 17	Lunokhod & roving surface vehicle.
Kosmos 377	70-96A	Nov. 11, 1970	TT	A-2	5,700?	305	208	65	[1] 89.4	Nov. 23, 1970	12	Military photo	Recovered.
Kosmos 378	70-97A	Nov. 17, 1970	PL	C-1	710?	1,763	241	74	[1] 105	Aug. 17, 1972	639	Geophysics	Ionospheric, cosmic rays.
Kosmos 379	70-99A	Nov. 24, 1970	TT	A-2m	7,495?	253	198	51.6	[1] 88.7			Man precursor	Extensive maneuvers possibly lunar-related.
						1,210	190	51.6	[2] 98.7				
							195	51.7	[2] 259.6				
Tyazheliy Sputnik	70-99C					14,035	189	51.6	[2] 88.5	Nov. 26, 1970	81	Launched Kosmos 379	
Kosmos 380	70-100A	Nov. 24, 1970	PL	B-1	250?	1,548	210	82	[1] 102.2	Jun. 17, 1971	205	Radar calibration	
Molniya 1-16	70-101A	Nov. 27, 1970	PL	A-2e	1,750?	39,430	435	65.3	[1] 707	Nov. 25, 1975	1824	Communications	
Tyazheliy Sputnik	70-101C				6,000?	434	216	65.4	[2] 91.0	Dec. 17, 1970	20	Launched Molniya	
Vertikal 1		Nov. 28, 1970	KY	SS-3	1,300	500 up			(1)	Nov. 28, 1970	0	Geophysical probe	Interkosmos.
Kosmos 381	70-102A	Dec. 2, 1970	PL	C-1	710?	1,023	985	74	[1] 105			Geophysics	Ionospheric, topside sounder.
Kosmos 382	70-103A	Dec. 2, 1970	TT	D-1m	10,380?	5,040	320	51.6	[1] 143			Man precursor	Extensive maneuvers, possibly lunar related.
						5,072	1,615	51.6	[2] 158.9				
						5,082	2,577	55.9	[2] 171.1				
Tyazheliy Sputnik	70-103C				18,000?	5.084	1,614	51.6	[2] 159.1			Launched Kosmos 382	
Kosmos 383	70-104A	Dec. 3, 1970	PL	A-2	6,300?	293	208	65.4	[1] 89.3	Dec. 16, 1970	13	Military photo	Recovered.
Kosmos 384	70-105A	Dec. 10, 1970	PL	A-2	5,900?	314	212	72.9	[1] 89.5	Dec. 22, 1970	12	Military photo	Pecovered.
Pickaback	70-105E				200?	271	204	72.9	[2] 89.3	Dec. 27, 1970	17		Radio telescope for passive microwave.
Kosmos 385	70-108A	Dec. 12, 1970	PL	C-1	680?	1,005	982	74	[1] 104.8			Navigation	1st Gen.
Kosmos 386	70-110A	Dec. 15, 1970	TT	A-2	6,300?	275	207	65	[1] 89.2	Dec. 28, 1970	13	Military photo	Recovered.
Kosmos 387	70-111A	Dec. 16, 1970	PL	C-1	875?	560	528	74	[1] 95.3	Jan. 19, 1980	3,321	Elint ferret	
Kosmos 388	70-112A	Dec. 18, 1970	PL	B-1	325?	532	281	71	[1] 92.3	May 10, 1971	143	Radar calibration	
Kosmos 389	70-113A	Dec. 18, 1970	PL	A-1	3,800?	699	655	81	[1] 98.1			Elint ferret	
Molniya 1-17	70-114A	Dec. 25, 1970	TT	A-2e	1,750?	39,600	480	65	[1] 712	Dec. 22, 1975	1,823	Communications	
Tyazheliy Sputnik	70-114C				6,000?	472	240	65.0	[2] 91.7	Feb. 10, 1971	47	Launched Molniya	
Kosmos 390	71-1A	Jan. 12, 1971	TT	A-2	6,300?	296	208	65	[1] 89.3	Jan. 25, 1971	13	Military photo	Recovered.
Kosmos 391	71-2A	Jan. 14, 1971	PL	B-1	300?	828	277	71	[1] 95.4	Feb. 21, 1972	403	Radar calibration	
Meteor 1-7	71-3A	Jan. 20, 1971	PL	A-1	3,800?	679	630	81.2	[1] 97.6			Meteorology	
Kosmos 392	71-4A	Jan. 21, 1971	TT	A-2	5,700?	300	207	65	[1] 89.4	Feb. 2, 1971	12	Military photo	Recovered.
Kosmos 393	71-7A	Jan. 26, 1971	PL	B-1	325?	512	283	71	[1] 92.2	June 16, 1971	141	Radar calibration	
Kosmos 394	71-10A	Feb. 9, 1971	PL	C-1	750?	619	574	65.9	[1] 96.5			Target for ASAT	
Kosmos 395	71-13A	Feb. 17, 1971	PL	C-1	875?	570	534	74	[1] 95.4	Apr. 6, 1980	3,336	Elint ferret	
Kosmos 396	71-14A	Feb. 18, 1971	PL	A-2	6,300?	310	211	65.4	[1] 89.4	Mar. 3, 1971	13	Military photo	Recovered.
Kosmos 397	71-15A	Feb. 25, 1971	TT	F-1m	3,320?	2,317	593	65.8	[1] 114.7			ASAT	Made close pass on Kosmos 394, then exploded.
Kosmos 398	71-16A	Feb. 26, 1971	TT	A-2m	7,255?	276	196	51.6	[1] 88.9			Man precursor	Extensive maneuvers possibly lunar-related.
						10,903	203	51.6	[2] 216.1				
Tyazheliy Sputnik	71-16C					1,188	186	51.6	[2] 98.5	May 12, 1971	75	Launched Kosmos 398	
Kosmos 399	71-17A	Mar. 3, 1971	TT	A-2	6,300?	310	209	65.0	[1] 89.5	Mar. 17, 1971	14	Military photo	Recovered.
Kosmos 400	71-20A	Mar. 18, 1971	PL	C-1	750?	1,016	995	65.8	[1] 105			Target for ASAT	

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 401	71-23A	Mar. 27, 1971	PL	A-2	6,300?	322	216	72.9	[1] 89.6	Apr. 9, 1971	13	Military photo	Recovered.
Kosmos 402	71-25A	Apr. 1, 1971	TT	F-1m	4,540	279	261	65	[1] 89.7			Radar ocean surveillance	Maneuvered up Apr. 19, 1971.
						1.036	948	65.0	104.9				
Kosmos 403	71-26A	Apr. 2, 1971	PL	A-2	5,700?	251	216	81.4	[1] 89	Apr. 14, 1971	12	Military photo	Recovered.
Kosmos 404	71-27A	Apr. 4, 1971	TT	F-1m	3,320?	1,009	811	65.9	[1] 103	Apr. 4, 1971		ASAT	Made close pass on Kosmos 400, then deboosted into Pacific.
						799	169	65.2	94.2				
Kosmos 405	71-28A	Apr. 7, 1971	PL	A-1	3,800?	706	676	81.3	[1] 98.3			Elint ferret	
Kosmos 406	71-29A	Apr. 14, 1971	PL	A-2	6,300?	264	223	81.3	[1] 89.2	Apr. 24, 1971	10	Military photo	Recovered.
Meteor 1-8	71-31A	Apr. 17, 1971	PL	A-1	3,800?	646	620	81.2	[1] 97.2			Meteorology	
Salyut 1	71-32A	Apr. 19, 1971	TT	D-1	18,300	222	200	51.6	[1] 89.6	Oct. 11, 1971	175	Manned Station	
						269	249	51.6					
Soyuz 10	71-34A	Apr. 22, 1971	TT	A-2	6,575?	246	208	51.6	[1] 89.6	Apr. 24, 1971	2	Manned	Shatalov, Yeliseyev, Rukavishnikov, recovered, docked with Salyut 1, but no entry.
Kosmos 407	71-35A	Apr. 23, 1971	PL	C-1	750?	844	799	74	[1] 101			Store-dump communications	
Kosmos 408	71-37A	Apr. 24, 1971	PL	B-1	250?	1,542	211	82	[1] 102.1	Dec. 29,1971	249	Radar calibration	
Kosmos 409	71-38A	Apr. 28, 1971	PL	C-1	600?	1,222	1,185	74	[1] 109.4			Geodetic	
Kosmos 410	71-40A	May 6, 1971	TT	A-2	5,900?	300	207	65	[1] 89.4	May 18, 1971	12	Military photo	Recovered.
Pickaback	71-40C				200?	264	197	65.0	[2] 89.1	May 25, 1971	19	Science	Particle flux, radiation.
Kosmos 411-418	71-41A-H	May 7, 1971	PL	C-1	50?	1,530	1,408	74.5	[1] 115			Tactical communication octuple launch.	
Kosmos 419	71-42A	May 10, 1971	TT	D-1e	4,650?	174	159	51.4	[1] 87.7	May 12, 1971	2	Mars	Failed to separate.
Tyazheliy Sputnik	71-42A				18,000?	174	159	51.4	[2] 87.7	May 12, 1971	2	Launched Kosmos 419	
Kosmos 420	71-43A	May 18, 1971	TT	A-2	6,300?	242	200	51.8	[1] 88.8	May 29, 1971	11	Military photo	Recovered.
Kosmos 421	71-44A	May 19, 1971	PL	B-1	325?	492	283	71	[1] 92	Nov. 8, 1971	173	Radar calibration	
Mars 2	71-45A	May 19, 1971	TT	D-1e	4,650	1.57au	0.99au	2.2	[2] [5] 530			Mars	Orbited Mars Nov. 27, 1971. (Orbital elements at Mars in parentheses).
						(25,000)	(1,380)	(18.9)	[2] (1098)				
Tyazheliy Sputnik	71-45C				18,000?	173	137	51.5	[2] 87.5	May 21, 1971	2	Launched Mars 2	
Lander	71-45E				1,100?					Nov. 27, 1971	192		Landed 44S, 47E on Mars.
Kosmos 422	71-46A	May 22, 1971	PL	C-1	680?	1,020	994	74	[1] 105.1			Navigation	1st Generation.
Kosmos 423	71-47A	May 27, 1971	PL	B-1	325?	511	282	71	[1] 92.2	Nov. 26, 1971	183	Radar calibration	
Kosmos 424	71-48A	May 28, 1971	PL	A-2	6,300?	309	214	65.4	[1] 89.4	Jan. 10, 1971	13	Military photo	Recovered.
Mars 3	71-49A	May 28, 1971	TT	D-1e	4,650	1.57au	0.99au	2.2	[2] [5] 530			Mars	Orbited Mars Dec. 2, 1971. (Orbital elements at Mars in parentheses).
						(190,700)	(1500)	(48.9)	[2] (15840)				
Tyazheliy Sputnik	71-49C				18,000?	234	140	51.6	[2] 88.2	May 31, 1971	3	Launched Mars 3	
Lander	71-49F				1,100?					Dec. 2, 1971	188		Landed 45S,158W on Mars.
Kosmos 425	71-50A	May 29, 1971	PL	C-1	870?	556	511	74	[1] 95.3	Jan. 15, 1980	3,153	Elint Ferret	
Kosmos 426	71-52A	June 4, 1971	PL	C-1	680?	2,012	394	74	[1] 109.3			Geophysics	Charged particles, fluxes, cosmic rays.
Soyuz 11	71-53A	June 6, 1971	TT	A-2	6,790?	217	185	51.6	[1] 88.3	June 29, 1971	24	Manned	Dobrovolskiy, Volkov, Patsayev died before recovery after stay in Salyut 1.
						264	256	51.6	89.7				
Kosmos 427	71-55A	June 11, 1971	PL	A-2	6,300?	337	211	72.9	[1] 89.7	June 23, 1971	12	Military photo	Recovered.

Kosmos 428	71-57A	June 24, 1971	TT	A-2	5,900?	271	208	51.8	[1] 89.1	July 6, 1971	12	Military photo	Recovered.
Pickaback	71-57G				200?	239	199	51.8	[2] 88.8	July 13, 1971	19		X-ray spectrometer.
Meteor 1-9	71-59A	July 16, 1971	PL	A-1	3,800?	650	618	81.2	[1] 97.3			Meteorology	
Kosmos 429	71-61A	July 20, 1971	TT	A-2	6,300?	260	204	51.8	[1] 89	Aug. 2, 1971	13	Military photo	Recovered.
Kosmos 430	71-62A	July 23, 1971	PL	A-2	6,300?	322	206	65.4	[1] 89.6	Aug. 5, 1971	13	Military photo	Recovered.
Molniya 1-18	71-64A	July 28, 1971	PL	A-2e	1,750?	39,300	470	65.4	[1] 705	July 19, 1977	2,183	Communications	
Tyazheliy Sputnik	71-64B				6,000?	459	217	65.4	[2] 91.3	Sept. 29, 1971	32	Launched Molniya	
Kosmos 431	71-65A	July 30, 1971	TT	A-2	5,700?	262	202	51.8	[1] 89	Aug. 11, 1971	12	Military photo	Recovered.
Kosmos 432	71-66A	Aug. 5, 1971	TT	A-2	6,300?	262	209	51.8	[1] 89	Aug. 18, 1971	13	Military photo	Recovered.
Kosmos 433	71-68A	Aug. 8, 1971	TT	F-1r	5,000?	259	159	49.5	[1] 88.5	Aug. 9, 1971	0	FOBS	
Kosmos 434	71-69A	Aug. 12, 1971	TT	A-2m	7,080?	285	147	51.6	[1] 89			Man precursor	Extensive maneuvers possibly luna-related.
						1,328	189	51.6	[2] 99.9				
						11,804	186	51.6	[2] 228.2				
Tyazheliy Sputnik	71-69E					1,328	189	51.6	[2] 99.9	Oct. 28, 1971	77	Launched Kosmos 434	
Vertikal 2		Aug. 20, 1971	KY	SS-3	1,300?	463up			(1)	Aug. 20, 1971	0	Geophysical probe	Interkosmos.
Kosmos 435	71-72A	Aug. 27, 1971	PL	B-1	325?	505	282	71	[1] 92.1	Jan. 28, 1972	154	Radar calibration	
Luna 18	71-73A	Sept. 2, 1971	TT	D-1e	5,600?	101	101	35	[2] 119	Sept. 11, 1971	9	Moon	Orbited Moon, but destroyed in soft landing attempt.
						100	18	35	[2] 114				
Tyazheliy Sputnik	71-73C				18,000?	242	186	51.6	[2] 88.7	Sept. 7, 1971	5	Launched Luna 18	
Sample returner	71-73				470?								Not launched from Moon.
Kosmos 436	71-74A	Sept. 7, 1971	PL	C-1	875?	550	514	74	[1] 95.2	Jan. 4, 1980	3,041	Elint ferret	
Kosmos 437	71-75A	Sept. 10, 1971	PL	C-1	875?	558	523	74	[1] 95.3	Mar. 29, 1980	3,123	Elint ferret	
Kosmos 438	71-77A	Sept. 14, 1971	PL	A-2	6,300?	321	212	65.4	[1] 89.5	Sept. 27, 1971	13	Military photo	Recovered.
Kosmos 439	71-78A	Sept. 21, 1971	PL	A-2	5,700?	308	219	65.4	[1] 89.4	Oct. 2, 1971	11	Military photo	Recovered.
Kosmos 440	71-79A	Sept. 24, 1971	PL	B-1	300?	814	282	71	[1] 95.3	Oct. 29, 1972	401	Radar calibration	
Unstated		Sept. 24, 1971	KY	SS-2	2,000?	230up			(1)	Sept. 24, 1971	0	Geophysical probe	
Kosmos 441	71-81A	Sept. 28, 1971	TT	A-2	6,300?	288	209	65	[1] 89.2	Oct. 10, 1971	12	Military photo	Recovered.
Luna 19	71-82A	Sept. 28, 1971	TT	D-1e	5,600?	140	140	40.6	[2] 121.8			Moon	Orbiter only. Returned pictures by radio.
						385	77	40.6	[2] 131				
Tyazheliy Sputnik	71-82B				18,000?	260	172	51.6	[2] 88.8	Oct. 1, 1971	3	Launched Luna 19	
Kosmos 442	71-84A	Sept. 29, 1971	PL	A-2	6,300?	321	211	72.9	[1] 89.5	Oct. 12, 1971	13	Military photo	Recovered.
Kosmos 443	71-85A	Oct. 7, 1971	PL	A-2	5,900?	325	211	65.4	[1] 89.6	Oct. 19, 1971	12	Military photo	Recovered.
Pickaback	71-85F				200?	225	186	65.4	[2] 88.6	Oct. 21, 1971	23		Science, radiation flux and particles.
Unstated		Oct. 9, 1971	KY		1,300?	500up			(1)	Oct. 9, 1971	0	Geophysical probe	
Kosmos 444-451	71-86A-H	Oct. 13, 1971	PL	C-1	50?	1,550	1415	74	[1] 115			Tactical communications octuple launch.	
Kosmos 452	71-88A	Oct. 14, 1971	TT	A-2	6,300?	270	201	65	[1] 89.1	Oct. 27, 1971	13	Military photo	Recovered.
Kosmos 453	71-90A	Oct. 19, 1971	PL	B-1	325?	522	281	71	[1] 92.2	Mar. 19, 1972	152	Radar calibration	
Kosmos 454	71-94A	Nov. 2, 1971	PL	A-2	6,300?	284	210	65.4	[1] 89.2	Nov. 16, 1971	14	Military photo	Recovered.
Kosmos 455	71-97A	Nov. 17, 1971	PL	B-1	325?	516	282	71	[1] 92.2	Apr. 9, 1972	144	Radar calibration	
Kosmos 456	71-98A	Nov. 19, 1971	PL	A-2	6,300?	328	218	72.9	[1] 89.7	Dec. 2, 1971	13	Military photo	Recovered.
Kosmos 457	71-99A	Nov. 20, 1972	PL	C-1	600?	1,229	1,192	74	[1] 109.5			Geodetic	
Molniya 2-1	71-100A	Nov. 24, 1971	PL	A-2e	1,800?	39,350	460	65.4	[1] 706.0	May 19, 1976	~ 1,634	Communications	
Tyazheliy Sputnik	71-100C				6,000?	465	225	65.4	[2] 91.4	Dec. 30, 1971	36	Launched Molniya	
Kosmos 458	71-101A	Nov. 29, 1971	PL	B-1	325?	523	281	71	[1] 92.3	Apr. 20, 1972	143	Radar calibration	
Kosmos 459	71-102A	Nov. 29, 1971	PL	C-1	750?	277	226	65.8	[1] 89.4	Dec. 27, 1971	28	Target for ASAT	

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 460	71-103A	Nov. 30, 1971	PL	C-1	875?	553	520	74	[1] 95.2	Mar. 5, 1980	3,018	Elint ferret	
Interkosmus 5	71-104A	Dec. 2, 1971	KY	B-1	340?	1,200	205	48.4	[1] 98.5	Apr. 7, 1972	127	Geophysics	Cosmic rays charged particles flux.
Kosmos 461	71-105A	Dec. 2, 1971	PL	C-1	680?	524	490	69.2	[1] 94.6	Feb. 21, 1978	2,638	Geophysics	Gamma rays.
Kosmos 462	71-106A	Dec. 3, 1971	TT	F-1m	3,320?	1,840	237	65/8	[1] 105.7	Apr. 4, 1975	1,218	ASAT	Close pass on Kosmos 459, exploded.
Kosmos 463	71-107A	Dec. 6, 1971	TT	A-2	6,300?	307	215	65.0	[1] 89.4	Dec. 11, 1971	5	Military photo	Recovered.
Kosmos 464	71-108A	Dec. 10, 1971	PL	A-2	6,300?	405	206	72.9	[1] 90.3	Dec. 16, 1971	6	Military photo	Recovered.
Kosmos 465	71-111A	Dec. 15, 1971	PL	C-1	680?	1,023	984	74	[1] 105			Navagation	1st Gen.
Kosmos 466	71-112A	Dec. 16, 1971	TT	A-2	6,300?	302	207	65	[1] 89.4	Dec. 27, 1971	11	Military pnoto	Recovered.
Kosmos 467	71-113A	Dec. 17, 1971	PL	B-1	325?	502	279	71	[1] 91	Apr. 18, 1972	123	Radar calibration	
Kosmos 468	71-114A	Dec. 17, 1971	PL	C-1	750?	830	788	74	[1] 100.8			Store-dump communications	
Molniya 1-19	71-115A	Dec. 19, 1971	PL	A-2e	1,750?	39,200	490	65.5	[1] 703	Apr. 13, 1977	1,942	Communications.	
Tyazheliy Sputnik	71-115D				6,000?	489	222	65.4	[2] 91.6	Jan. 27, 1972	39	Launched Molniya	
Kosmos 469	71-117A	Dec. 25, 1971	TT	F-1m	4,540?	276	259	65	[1] 89.7			Radar ocean surveillance	Moved up Jan. 4, 1972.
						1,023	941	64.5	[2] 104.7				
Kosmos 470	71-118A	Dec. 27, 1971	PL	A-2	5,900?	272	195	65.4	[1] 89.1	Jan. 6, 1972	10	Military photo	Recovered, first of new series.
Pickaback	71-118C				200?	211	183	65.4	[2] 88.4	Jan. 6, 1972	10		Possible mapping, resources collection low resolution, two-tone format.
Oreol 1	71-119A	Dec. 27, 1971	PL	C-1	630?	2,500	410	74	[1] 114.6			Geophysics	French Aureole Study.
Meteor 1-10	71-120A	Dec. 29, 1971	PL	A-1	3,300?	905	880	81.2	[1] 102.7			Meteorology	
Kosmos 471	72-1A	Jan. 12, 1972	TT	A-2	6,300?	323	202	65	[1] 89.7	Jan. 25, 1972	13	Military photo	Recovered.
Kosmos 472	72-4A	Jan. 25, 1972	PL	B-1	250?	1,568	207	82	[1] 102.4	Aug. 8, 1972	206	Radar calibration	
Kosmos 473	72-6A	Feb. 3, 1972	TT	A-2	5,700?	333	209	65	[1] 89.7	Feb. 15, 1972	12	Military photo	Recovered.
Luna 20	72-7A	Feb. 14, 1972	TT	D-1e	5,600?	100	100	65	[2] 118	Feb. 21, 1972	7	Moon	Orbited Moon, then soft landed.
						100	21	65	[2] 114				
Tyazheliy Sputnik	72-7C				18,000?	238	191	51.5	[2] 88.7	Feb. 17, 1972	4	Launched Luna 20	
Sample returner	72-7F	Feb. 22, 1972	Moon		470?					Feb. 25, 1972	3		Recovered in U.S.S.R.
Kosmos 474	72-8A	Feb. 16, 1972	TT	A-2	6,300?	347	207	65	[1] 89.8	Feb. 29, 1972	13	Military photo	Recovered.
Kosmos 475	72-9A	Feb. 25, 1972	PL	C-1	680?	1,013	977	74	[1] 105			Navagation	1st Gen.
Kosmos 476	72-11A	Mar. 1, 1972	PL	A-1	3,800?	651	618	81.2	[1] 97.2			Elint ferret	
Kosmos 477	72-13A	Mar. 4, 1972	PL	A-2	5,900?	328	212	72.9	[1] 89.6	Mar. 18, 1972	12	Military photo	Recovered.
Pickaback	72-13E				200?	292	199	72.9	[2] 89.4	Mar. 5, 1972	19		Radiation, particle fluxes.
Kosmos 478	72-15A	Mar. 15, 1972	PL	A-2	6,300?	319	213	65.4	[1] 89.5	Mar. 28, 1972	13	Military photo	Recovered.
Kosmos 479	72-17A	Mar. 22, 1972	PL	C-1	875	549	517	74	[1] 95.2	Apr. 13, 1980	2,944	Elint ferret	
Kosmos 480	72-19A	Mar. 25, 1972	PL	C-1	600	1,212	1,183	83	[1] 109.2			Geodetic	
Kosmos 481	72-20A	Mar. 25, 1972	PL	B-1	375?	540	279	71	[1] 92.4	Sept. 2, 1972	161	Geophysics	Geomagnetic.
Venera 8	72-21A	Mar. 27, 1972	TT	A-2e	1,180	1.08au	0.72au	2	[2] [5] 313	July 22, 1972	117	Venus	Soft landed on Venus, sent data from surface.
Tyazheliy Sputnik	72-21C				6,540?	241	194	51.8	[2] 88.6	Mar. 29, 1972	3	Launched Venera 8	
Meteor 1-11	72-22A	Mar. 30, 1972	PL	A-1	3,300?	903	878	81.2	[1] 102.6			Meteorology	
Kosmos 482	72-23A	Mar. 31, 1972	TT	A-2e	1,180?	9,813	210	52	[1] 201.4			Venus	Failed to fly to Venus.
Tyazheliy Sputnik	72-23C				6,540?	237	179	51.7	[2] 88.6	Apr. 2, 1972	2	Launched Kosmos 482	
Kosmos 483	72-24A	Apr. 3, 1972	PL	A-2	6,300?	345	212	72.9	[1] 89.8	Apr. 15, 1972	12	Military photo	Recovered.
Molniya 1-20	72-25A	Apr. 4, 1972	PL	A-2e	1,750?	39,260	480	65.6	[1] 695	Jan. 30, 1974	666	Communications	
MAS 1	72-25B				15	39,250	458	65.6	[2] 704.7	Feb. 26, 1974	693		French SRET solar cell development study.
Tyazheliy Sputnik	72-25D				6,000?	473	231	65.5	[2] 91.6	May 8, 1972	33	Launched Molniya	
Kosmos 484	72-26A	Apr. 5, 1972	PL	A-2	5,900?	236	203	81.3	[1] 88.8	Apr. 18, 1972	12	Military photo	Recovered.
Pickaback	72-26C				200?	179	170	81.3	[2] 88.0	Apr. 18, 1972	13		Science, solar radiation and cosmic ray study.

Interkosmos 6	72-27A	Apr. 7, 1972	TT	A-2	5,700?	256	203	51.8	[1]89	Apr. 11, 1972	4	Geophysics	High energy cosmic ray study, recovered.
Kosmos 485	72-28A	Apr. 11, 1972	PL	B-1	325?	506	280	71	[1]92.1	Aug. 30, 1972	141	Radar calibration	
Prognoz 1	72-29A	Apr. 14, 1972	TT	A-2e	845	200,000	950	65	[1]5,820			Geophysics	Solar wind and Earth field interactions.
Tyazheliy Sputnik	72-29C				6,000?	459	228	65.0	[2]91.4	May 17, 1972	33	Launched Prognoz 1	
Kosmos 486	72-30A	Apr. 14, 1972	PL	A-2	6,300?	267	214	81.4	[1]89.1	Apr. 27, 1972	4	Military photo	Recovered.
Kosmos 487	72-33A	Apr. 21, 1972	PL	B-1	325?	531	278	71	[1]92.3	Sept. 24, 1972	156	Radar calibration	
Kosmos 488	72-34A	May 5, 1972	PL	A-2	6,300?	319	211	65.4	[1]89.5	May 18, 1972	13	Military photo	Recovered.
Kosmos 489	72-35A	May 6, 1972	PL	C-1	680	1,010	980	74	[1]105			Navigation	1st Gen.
Kosmos 490	72-36A	May 17, 1972	PL	A-2	5,900?	310	212	65.4	[1]89.4	May 29, 1972	12	Military photo	Recovered.
Pickaback	72-36D				200?	268	202	65.4	[2]89.2	June 6, 1972	20		Science, high-energy electron, flux, cosmic rays.
Molniya 2-2	72-37A	May 19, 1972	PL	A-2e	1,800?	39,300	460	65.5	[1]705	Mar. 22, 1977	1,768	Communications	
Tyazheliy Sputnik	72-37C				6,000?	463	207	65.4	[2]91.2	June 9, 1972	21	Launched Molniya	
Kosmos 491	72-38A	May 25, 1972	TT	A-2	6,300?	303	210	65	[1]89.5	June 8, 1972	14	Military photo	Recovered.
Kosmos 492	72-40A	June 9, 1972	TT	A-2	6,300?	342	209	65	[1]89.8	June 22, 1972	13	Military photo	Recovered.
Kosmos 493	72-42A	June 21, 1972	TT	A-2	5,700?	308	213	65	[1]89.5	July 3, 1972	12	Military photo	Recovered.
Kosmos 494	72-43A	June 23, 1972	PL	C-1	750?	829	791	74	[1]100.8			Store-dump communications	
Kosmos 495	72-44A	June 23, 1972	PL	A-2	6,300?	298	206	65.4	[1]89.3	July 6, 1972	13	Military photo	Recovered.
Kosmos 496	72-45A	June 26, 1972	TT	A-2	6,570?	342	195	51.6	[1]89.6	July 2, 1972	6	Manned precursor	Unmanned Soyuz test flight.
Prognoz 2	72-46A	June 29, 1972	TT	A-2e	845	200,000	550	65	[1]5,820			Geophysics	
Tyazheliy Sputnik	72-46C				6,000?	469	235	64.9	[2]91.6	Aug. 13, 1972	45	Launched Prognoz	
Interkosmos 7	72-47A	June 30, 1972	KY	B-1	375	568	267	48.4	[1]92.6	Oct. 5, 1972	97	Geophysics	Shortwave, solar radiation, heat, X-rays.
Kosmos 497	72-48A	June 30, 1972	PL	B-1	300?	812	282	91	[1]95.2	Nov. 7, 1973	495	Radar calibration	
Meteor 1-12	72-49A	June 30, 1972	PL	A-1	3,300?	929	897	81.2	[1]103			Meteorology	
Kosmos 498	72-50A	July 5, 1972	PL	B-1	325?	511	282	71	[1]92.1	Nov. 25, 1972	143	Radar calibration	
Kosmos 499	72-51A	July 6, 1972	TT	A-2	6,300?	283	209	51.8	[1]89.2	July 17, 1972	11	Military photo	Recovered.
Kosmos 500	72-53A	July 10, 1972	PL	C-1	875?	554	509	74	[1]95.2	Mar. 29, 1980	2,819	Elint ferret	
Kosmos 501	72-54A	July 12, 1972	KY	B-1	250?	2,149	222	48.5	[1]108.8	May 9, 1974	667	Radar calibration	
Kosmos 502	72-55A	July 13, 1972	PL	A-2	5,900?	284	206	65.4	[1]89.2	July 25, 1972	12	Military photo	Recovered, mapping, geodesy resources.
Pickaback	72-55E				200?	233	171	65.4	[2]88.5	July 26, 1972	13		
Kosmos 503	72-56A	July 19, 1972	PL	A-2	6,300?	304	208	65.4	[1]89.4	Aug. 1, 1972	13	Military photo	Recovered.
Kosmos 504-511	72-57A-H	July 20, 1972	PL	C-1	50?	1,540	1,425	74	[1]115.2			Tactical communicatios octuple launch.	
Kosmos 512	72-59A	July 28, 1972	PL	A-2	5,700?	294	207	65.4	[1]89.3	Aug. 9, 1972	12	Military photo	Recovered.
Kosmos 513	72-60A	Aug. 2. 1972	TT	A-2	6,300?	340	209	65	[1]89.8	Aug. 15, 1972	13	Military photo	Recovered.
Kosmos 514	72-62A	Aug. 16, 1972	PL	C-1	680?	999	959	83	[1]104.4			Navigation	2d Gen. "A".
Kosmos 515	72-63A	Aug. 18, 1972	PL	A-2	6,300?	300	203	72.9	[1]89.3	Aug. 31, 1972	13	Military photo	Recovered.
Kosmos 516	72-66A	Aug. 21, 1972	TT	F-1m	4,540?	277, 1,030	256 920	65 64.8	[1]89.6 [2]104.6			Radar ocean surveillance	Moved up Sept. 21, 1972.
Kosmos 517	72-67A	Aug. 30, 1972	TT	A-2	5,700?	305	207	65	[1]89.4	Sept. 11, 1972	12	Military photo	Recovered.
Kosmos 518	72-70A	Sept. 15, 1972	PL	A-2	5,900?	330	208	72.9	[1]89.6	Sept. 24, 1972	9	Military photo	Recovered.
Pickaback	72-70C				200?	278	200	72.9	[2]89.3	Sept. 27, 1972	12		Sciences.

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 519	72-71A	Sept. 16, 1972	TT	A-2	6,300?	343	210	71.3	[1] 89.8	Sept. 26, 1972	10	Military photo	Recovered.
Kosmos 520	72-72A	Sept. 19, 1972	PL	A-2e	1,800?	39,319	652	62.8	[1] 710			Early warning	
Tyazheliy Sputnik	72-72C				6,000?	607	214	62.8	[2] 92.8	Nov. 5, 1972	47	Launched Kosmos 520	
Kosmos 521	72-74A	Sept. 29, 1972	PL	C-1	750?	1,030	973	65.8	[1] 105			Target for ASAT	No sign of an interception.
Molniya 2-3	72-75A	Sept. 30, 1972	PL	A-2e	1,800?	39,200	480	65.3	[1] 703	Jan. 12, 1978	1,930	Communications	
Tyazheliy Sputnik	72-75C				6,000?	466	230	65.4	[2] 91.5	Nov. 1, 1972	32	Launched Molniya	
Kosmos 522	72-77A	Oct. 4, 1972	PL	A-2	6,300?	342	214	72.9	[1] 89.8	Oct. 17, 1972	13	Military photo	Recovered.
Kosmos 523	72-78A	Oct. 5, 1972	PL	B-1	325?	507	283	71	[1] 92	Mar. 7, 1973	153	Radar calibration	
Kosmos 524	72-80A	Oct. 11, 1972	PL	B-1	325?	537	277	71	[1] 92.3	Mar. 25, 1973	165	Radar calibration	
Molniya 1-21	72-81A	Oct. 14, 1972	PL	A-2e	1,750?	39,300	480	65.3	[1] 705	Nov. 1, 1977	1,844	Communications	
Tyazheliy Sputnik	72-81C				6,000?	488	223	65.4	[2] 91.7	Nov. 16, 1972	33	Launched Molniya	
Kosmos 525	72-83A	Oct. 18, 1972	PL	A-2	5,900?	292	208	65.4	[1] 89.3	Oct. 29, 1972	11	Military photo	Recovered.
Pickaback	72-83C				200?	260	192	65.4	[2] 89.0	Nov. 1, 1972	14	Science	Sciences.
Kosmos 526	72-84A	Oct. 25, 1972	PL	B-1	325?	511	282	71	[1] 92	Apr. 8, 1973	165	Radar calibration	
Meteor 1-13	72-85A	Oct. 26, 1972	PL	A-1	3,300?	904	893	81.2	[1] 102.6			Meteorology	
Kosmos 527	72-86A	Oct. 31, 1972	PL	A-2	6,300?	330	214	65.4	[1] 89.7	Nov. 13, 1972	13	Military photo	Recovered.
Kosmos 528-535	72-87A-H	Nov. 1, 1972	PL	C-1	50?	1,495	1,375	74	[1] 114			Tactical communications octuple launch.	
Kosmos 536	72-88A	Nov. 3, 1972	PL	C-1	875?	555	514	74	[1] 95.2	July 20, 1980	2,816	Elint ferret	
Kosmos 537	72-93A	Nov. 25, 1972	TT	A-2	5,700?	324	207	65	[1] 89.6	Dec. 7, 1972	12	Military photo	Recovered.
Interkosmos 8	72-94A	Nov. 30, 1972	PL	B-1	340?	679	214	71	[1] 93.2	Mar. 2, 1973	92	Geophysics	Ions, electrons, protons of high energy.
Molniya 1-22	72-95A	Dec. 2, 1972	TT	A-2e	1,750?	39,100	500	65	[1] 703	Feb. 11, 1976	1,166	Communications	
Tyazheliy Sputnik	72-95C				6,000?	531	210	65	[2] 91.3	Feb. 1, 1973	62	Launched Molniya	
Molniya 2-4	72-98A	Dec. 12, 1972	PL	A-2e	1,800?	39,300	470	65.3	[1] 705	Jan. 22, 1975	771	Communications	
Tyazheliy Sputnik	72-98C				6,000?	467	220	65.4	[2] 91.4	Jan. 19, 1973	38	Launched Molniya	
Kosmos 538	72-99A	Dec. 14, 1972	PL	A-2	6,300?	305	212	65.4	[1] 89.4	Dec. 27, 1972	13	Military photo	Recovered.
Kosmos 539	72-102A	Dec. 21, 1972	PL	C-1	600?	1,353	1,302	74	[1] 113			Geodetics	
Kosmos 540	72-104A	Dec. 25, 1972	PL	C-1	750?	823	779	74	[1] 100.8			Store-dump communication	
Kosmos 541	72-105A	Dec. 27, 1972	PL	A-2	5,900?	371	242	81.4	[1] 90.3	Jan. 8, 1973	12	Military photo	Recovered, mapping, geodesy, resources.
Pickaback	72-105F				200?	323	220	81.3	[2] 89.9	Jan. 15, 1973	19		
Kosmos 542	72-106A	Dec. 28, 1972	PL	A-1	3,800?	653	554	81.2	[1] 96.4			Elint ferret	New generation of larger payload.
Luna 21	73-1A	Jan. 8, 1973	TT	D-1e	5,600?	110	90	60	[2] 118	Jan. 15, 1973	7	Moon	Orbited Moon, landed Lunokhod 2 roving laboratory at (840 kg) 26.5N. 30.6E.
						110	16	60	[2] 114				
Tyazheliy Sputnik	73-1C				18,000?	236	183	51.6	[2] 88.6	Jan. 13, 1973	5	Launched Luna 21	
Kosmos 543	73-2A	Jan. 11, 1973	TT	A-2	6,300?	333	211	65	[1] 89.7	Jan. 24, 1973	13	Military photo	Recovered.
Kosmos 544	73-3A	Jan. 20, 1973	PL	C-1	875?	561	513	74	[1] 95.3	June 15, 1980	2,703	Elint ferret	
Kosmos 545	73-4A	Jan. 24, 1973	PL	B-1	325?	521	279	71	[1] 92.2	July 31, 1973	188	Radar calibration	
Kosmos 546	73-5A	Jan. 26, 1973	KY	C-1	925?	630	585	50.7	[1] 96.6			Geophysics	First launch of C-1 at Kapustin Yar.
Kosmos 547	73-6A	Feb. 1, 1973	TT	A-2	5,700?	330	208	65	[1] 89.7	Feb. 13, 1973	12	Military photo	Recovered.

Molniya 1-23	73-7A	Feb. 3, 1973	TT	A-2e	1,750?	39,200	470	65	[1]703	Oct. 23, 1977	1,723	Communications	
Tyazheliy Sputnik	73-7C				6,000?	472	228	65.0	[2]91.5	Mar. 18, 1973	43	Launched Molniya	
Kosmos 548	73-8A	Feb. 8, 1973	PL	A-2	6,300?	322	214	65.4	[1]89.6	Feb. 21, 1973	13	Military photo	Recovered.
Prognoz 3	73-9A	Feb. 15, 1973	TT	A-2e	845?	200,000	590	65	[1]5,783			Geophysics	Interaction of solar wind and Earth's magnetosphere.
Tyazheliy Sputnik	73-9C				6,000?	484	216	65.0	[2]91.5	Mar. 23, 1973	32	Launched Prognoz	
Kosmos 549	73-10A	Feb. 28, 1973	PL	C-1	875?	556	513	74	[1]95.2	June 29, 1980	2,678	Elint ferret	
Kosmos 550	73-11A	Mar. 1, 1973	PL	A-2	6,300?	325	217	65.4	[1]89.6	Mar. 11, 1973	10	Military photo	Recovered.
Kosmos 551	73-12A	Mar. 6, 1973	TT	A-2	6,300?	316	210	65	[1]89.5	Mar. 20, 1973	14	Military photo	Recovered.
Meteor 1-14	73-15A	Mar. 20, 1973	PL	A-1	3,300?	903	882	81.2	[1]102.6			Meteorology	
Kosmos 552	73-16A	Mar. 22, 1973	PL	A-2	5,900?	337	211	72.9	[1]89.7	Apr. 3, 1973	12	Military photo	Recovered.
Pickaback	73-16C				200?	310	199	72.9	[2]89.6	Apr. 9, 1973	18		Science.
Salyut 2	73-17A	Apr. 3, 1973	TT	D-1	18,600?	260	215	51.6	[1]89	May 28, 1973	55	Manned Station	Military version of Salyut, disabled before manned docking, commanded to reenter.
						278	257	51.6	[2]89.8				
Molniya 2-5	73-18A	Apr. 5, 1973	PL	A-2e	1,800?	39,100	500	65	[1]702	Jan. 6, 1979	2,102	Communications	
Tyazheliy Sputnik	73-18C				6,000?	456	217	65.4	[2]91.3	Apr. 30, 1973	25	Launched Molniya	
Kosmos 553	73-20A	Apr. 12, 1973	PL	B-1	325?	519	282	71	[1]92.2	Nov. 11, 1973	213	Radar calibration	
Kosmos 554	73-21A	Apr. 19, 1973	PL	A-2	6,300?	318	212	72.9	[1]89.5	May 27, 1973	38	Military photo	Exploded, not recovered.
Interkosmos 9, Kopernik 500.	73-22A	Apr. 19, 1973	KY	B-1	340?	1551	202	48.5	[1]102.2	Oct. 19, 1973	179	Geophysics	Solar radiation and ionosphere measurements.
Kosmos 555	73-24A	Apr. 25, 1973	PL	A-2	5,900?	253	216	81.3	[1]89	May 7, 1973	12	Military photo	Recovered.
Pickaback	73-24D				200?	222	209	81.3	[2]88.8	May 9, 1973	14		Science.
Kosmos 556	73-25A	May 5, 1973	PL	A-2	6,300?	252	209	81.3	[1]89	May 14, 1973	9	Military photo	Recovered.
Kosmos 557	73-26A	May 11, 1973	TT	D-1	18,600?	266	218	51.6	[1]89.1	May 22, 1973	11	Salyut manned station	Civilian version of Salyut, failed early in mission.
Kosmos 558	73-29A	May 17, 1973	PL	B-1	325?	526	279	71	[1]92.3	Dec. 22, 1973	219	Radar celibration	
Kosmos 559	73-30A	May 18, 1973	PL	A-2	6,300?	345	217	65.4	[1]89.8	May 23, 1973	5	Military photo	Recovered.
Kosmos 560	73-31A	May 23, 1973	PL	A-2	6,300?	336	211	72.9	[1]89.7	June 5, 1973	13	Military photo	Recovered.
Kosmos 561	73-33A	May 25, 1973	PL	A-2	5,900?	317	215	65.4	[1]89.5	June 6, 1973	12	Military photo	Recovered.
Pickaback	73-33D				200?	283	206	65.4	[2]89.4	June 20, 1973	26		Science, gamma ray telescope for galactic studies.
Meteor 1-15	73-34A	May 29, 2973	PL	A-1	3,300?	909	867	81.2	[1]102.5			Meteorolgy	
Kosmos 562	73-35A	June 5, 1973	PL	B-1	325?	510	282	71	[1]92.1	Jan. 7, 1974	216	Radar calibration	
Kosmos 563	73-36A	June 6, 1973	PL	A-2	6,300?	320	213	65.4	[1]89.5	June 18, 1973	12	Military photo	Recovered.
Kosmos 564-571	73-37A-H	June 8, 1973	PL	C-1	50?	1,507	1,392	74	[1]114.5			Tactical communications octuple launch.	
Kosmos 572	73-38A	June 10, 1973	TT	A-2	6,300?	294	211	51.7	[1]89.3	June 23, 1973	13	Military photo	Recovered.
Kosmos 573	73-41A	June 15, 1973	TT	A-2	6,570?	329	196	51.6	[1]89.5	June 17, 1973	2	Man precursor	Test flight of Soyuz ferry craft.
Kosmos 574	73-42A	June 20, 1973	PL	C-1	680?	1,026	996	83	[1]105			Navigation	2d Gen. "A".
Kosmos 575	73-43A	June 21, 1973	PL	A-2	5,700?	299	208	65.4	[1]89.3	July 3, 1973	12	Military photo	Recovered.
Kosmos 576	73-44A	June 27, 1973	PL	A-2	5,900?	356	212	72.9	[1]89.9	July 9, 1973	12	Military photo	Recovered, mapping geodesy resources.
Pickaback	73-44H				200?	478	212	72.9	[2]91.4	July 14, 1973	17		
Molniya 2-6	73-45A	July 11, 1973	PL	A-2e	1,800?	39,280	480	65.3	[1]705	July 7, 1978	1,822	Communications	
Tyazheliy Sputnik	73-45B				6,000?	463	221	65.4	[2]91.4	Aug. 22, 1973	42	Launched Molniyd	

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Mars 4	73-47A	July 21, 1973	TT	D-1e	3,440?	1.63au	1.02au	2.2	[2,5] 556			Mars	Passed Mars at 2,200 km Feb. 10, 1974 but failed to enter Mars' orbit as planned.
Tyazheliy Sputnik	73-47C				18.000?	179	147	51.5	[2] 87.7	July 26, 1973	5	Launched Mars 4	
Kosmos 577	73-48A	July 25, 1973	PL	A-2	6,300?	312	209	65.4	[1] 89.5	Aug. 7, 1973	13	Military photo	Recovered.
Mars 5	73-49A	July 25, 1973	TT	D-1e	3,440?	1.65au	1.01au	2.2	[2,5] 560			Mars	Orbited Mars Feb. 2, 1974 to gather Mars data and to serve as relay station. (Orbital parameters at Mars in parentheses.)
						(32.500)	(1,760)	(35)	[2] (1,493)				
Tyazheliy Sputnik	73-49C				18.000?	174	159	51.6	[2] 87.8	July 27, 1973	2	Launched Mars 5	
Kosmos 578	73-51A	Aug. 1, 1973	PL	A-2	5,700?	308	207	65.4	[1] 89.4	Aug. 13, 1973	12	Military photo	Recovered.
Mars 6	73-52A	Aug. 5, 1973	TT	D-1e	3,260?	1.67au	1.01au	2.2	[2,5] 567			Mars	
Tyazheliy Sputnik	73-52C				18,000?	193	154	51.5	[2] 87.9	Aug. 7, 1973	2	Launched Mars 6	
Lander	73-52E				1,200?					Mar. 12, 1974	219		Soft landed at 24S, 25W, returned atmospheric data on way down.
Mars 7	73-53A	Aug. 9, 1973	TT	D-1e	2,260?	1.69au	1.01au	2.2	[2,5] 574			Mars	
Tyazheliy Sputnik	73-53C				18,000?	193	154	51.5	[2] 87.9	Aug. 11, 1973	2	Launched Mars 7	
Lander	73-53E				1,200?								Missed Mars by 1,300 km (aimed at 50S, 28W.)
Kosmos 579	73-55A	Aug. 21, 1973	PL	A-2	6,300?	315	209	65.4	[1] 89.5	Sept. 3, 1973	13	Military photo	Recovered.
Kosmos 580	73-57A	Aug. 22, 1973	PL	B-1	325?	518	283	71	[1] 92.2	Apr. 1, 1974	222	Radar calibration	
Kosmos 581	73-59A	Aug. 24, 1973	TT	A-2	6,300?	303	211	51.6	[1] 89.4	Sept. 6, 1973	13	Military photo	Recovered.
Kosmos 582	73-60A	Aug. 28, 1973	PL	C-1	875?	559	521	74	[1] 95.3	Sept. 5, 1980	2,565	Elint ferret	
Molniya 1-24	73-61A	Aug. 30, 1973	PL	A-2e	1,750?	37,970	480	65.3	[1] 679	Apr. 10, 1979	2,049	Communications	
Tyazheliy Sputnik	73-61C				6,000?	481	223	65.4	[2] 91.6	Oct. 8, 1973	38	Launched Molniya	
Kosmos 583	73-62A	Aug. 30, 1973	TT	A-2	5,700?	316	208	65	[1] 89.5	Sept. 12, 1973	13	Military photo	Recovered.
Kosmos 584	73-63A	Sept. 6, 1973	PL	A-2	6,300?	360	213	72.9	[1] 89.9	Sept. 20, 1973	14	Military photo	Recovered.
Kosmos 585	73-64A	Sept. 8, 1973	PL	C-1	600?	1,416	1,385	74	[1] 1136			Geodetic	
Kosmos 586	73-65A	Sept. 14, 1973	PL	C-1	680?	1,020	986	83	[1] 105			Navigation	2d Gen. "A".
Kosmos 587	73-66A	Sept. 21, 1973	PL	A-2	6,300?	330	215	65.4	[1] 89.6	Oct. 4, 1973	13	Military photo	Recovered.
Soyuz 12	73-67A	Sept. 27, 1973	TT	A-2	6,570?	249	194	51.6	[1] 88.6	Sept. 29, 1973	2	Manned	Lazarez, Makarov recovered, test of ferry version.
						345	326	51.6	[2] 91.2				
Kosmos 588-595	73-69A-H	Oct. 2, 1973	PL	C-1	50?	1,512	1,397	74	[1] 115			Tactical communications octuple launch.	
Kosmos 596	73-70A	Oct. 3, 1973	PL	A-2	5,700?	310	211	65.4	[1] 89.4	Oct. 9, 1973	6	Military photo	Recovered.
Kosmos 597	73-71A	Oct. 6, 1973	PL	A-2	6,300?	312	212	65.4	[1] 89.5	Oct. 12, 1973	8	Military photo	Recovered
Kosmos 598	73-72A	Oct. 10, 1973	PL	A-2	6,300?	360	213	72.9	[1] 90	Oct. 16, 1973	6	Military photo	Recovered.
Kosmos 599	73-73A	Oct. 15, 1973	TT	A-2	5,700?	294	206	65	[1] 89.3	Oct. 28, 1973	13	Military photo	Recovered.
Kosmos 600	73-74A	Oct. 16, 1973	PL	A-2	6,300?	366	215	72.9	[1] 90	Oct. 23, 1973	7	Military photo	Recovered.
Kosmos 601	73-75A	Oct. 16, 1973	PL	B-1	250?	1,561	210	82	[1] 102.3	Aug. 15, 1974	303	Radar calibration	
Molniya 2-7	73-76A	Oct. 19, 1973	PL	A-2e	1,800?	40,600	630	62.8	[1] 736			Communications	
Tyazheliy Sputnik	73-76C				6,000?	599	209	62.8	[2] 92.6	Dec. 18, 1973	60	Launched Molniya	

Kosmos 602	73-77A	Oct. 20, 1973	PL	A-2	6,300?	365	213	72.9	[1] 90	Oct. 29, 1973	9	Military photo	Recovered.
Kosmos 603	73-79A	Oct. 27, 1973	PL	A-2	6,300?	380	214	72.9	[1] 90.1	Nov. 9, 1973	13	Military photo	Recovered.
Kosmos 604	73-80A	Oct. 29, 1973	PL	A-1	3,800?	647	624	81.2	[1] 97.2			Elint ferret	
Interkosmos 10	73-82A	Oct. 30, 1973	PL	C-1	340	1,.477	265	74	[1] 102	July 1, 1977	1,340	Geophysics	Ionosphere electrons field variations.
Kosmos 605	73-83A	Oct. 31, 1973	PL	A-2	5,500?	424	221	62.8	[1] 90.7	Nov. 22, 1973	22	Biology	Recovered.
Pickaback	73-83C				200?	379	193	62.3	[2] 90.2	Jan. 16. 1974	77		
Kosmos 606	73-84A	Nov. 2, 1973	PL	A-2e	1,800?	39,360	626	62.8	[1] 710			Early warning	
Tyazheliy Sputnik	73-84C				6,000?	621	215	62.8	[2] 92.9	Jan. 29, 1974	88	Launched Kosmos 606	
Kosmos 607	73-87A	Nov. 10, 1973	PL	A-2	6,300?	364	214	72.9	[1] 90	Nov. 22, 1973	12	Military photo	Recovered.
Molniya 1-25	73-89A	Nov. 14, 1973	TT	A-2e	1,750?	39,140	480	65	[1] 702	Aug. 16, 1979	2,101	Communications	
Tyazheliy Sputnik	73-89D				6,000?	476	241	64.9	[2] 91.7	Jan. 26, 1974	73	Launched Molniya	
Kosmos 608	73-91A	Nov. 20, 1973	PL	B-1	325?	528	281	71	[1] 92.3	July 10, 1974	232	Radar calibration	
Kosmos 609	73-92A	Nov. 21, 1973	TT	A-2	6,300?	370	207	70	[1] 90	Dec. 4, 1973	13	Military photo	Recovered.
Kosmos 610	73-93A	Nov. 27, 1973	PL	C-1	875?	560	515	74	[1] 95.2	Sept. 15, 1980	2,484	Elint ferret	
Kosmos 611	73-94A	Nov. 28, 1973	PL	B-1	325?	507	280	71	[1] 92	June 19, 1974	203	Radar calibration	
Kosmos 612	73-95A	Nov. 28, 1973	PL	A-2	6,300?	371	214	72.9	[1] 90.1	Dec. 11, 1973	13	Military photo	Recovered.
Kosmos 613	73-96A	Nov. 30, 1973	TT	A-2	6,570?	295	195	51.6	[1] 89.7	Jan. 29, 1974	60	Man precursor	Soyuz test of long stay time in orbit, recovered.
						396	255	51.6	[2] 91.0				
Molniya 1-26	73-97A	Nov. 30, 1973	PL	A-2e	1,750?	40,900	460	62.7	[1] 737			Communications	
Tyazheliy Sputnik	73-97C				6,000?	440	207	62.8	[2] 91.0	Dec. 31, 1973	31	Launched Molniya	
Kosmos 614	73-98A	Dec. 4, 1973	PL	C-1	750?	830	770	74	[1] 100.7			Store-dump communications	
Kosmos 615	73-99A	Dec. 13, 1973	PL	B-1	300?	859	280	71	[1] 95.7	Dec. 17, 1975	734	Radar calibration	
Kosmos 616	73-102A	Dec. 17, 1973	PL	A-2	5,900?	355	214	72.9	[1] 89.9	Dec. 28, 1973	11	Military photo	Recovered, Mapping, geodesy, resources.
Pickaback	73-102E				200?	301	197	72.9	[2] 89.5	Jan. 2, 1974	16		
Soyuz 13	73-103A	Dec. 18, 1973	TT	A-2	6,680?	247	188	51.6	[2] 88.8	Dec. 26, 1973	8	Manned	Klimuk, Lebedev recovered, astronomical observatory.
						276	225	51.6	[1] 89.2				
Kosmos 617-624	73-104A-H	Dec. 19, 1973	PL	C-1	50?	1,511	1,404	74	[1] 114.8			Tactical communications octuple launch.	
Kosmos 625	73-105A	Dec. 21, 1973	PL	A-2	6,300?	346	214	72.8	[1] 89.8	Jan. 3, 1974	13	Military photo	Recovered.
Molniya 2-8	73-106A	Dec. 25, 1973	PL	A-2e	1,800?	40,865	466	62.8	[1] 737			Communications	
Tyazheliy Sputnik	73-106B				6,000?	450	194	62.8	[2] 91.0	Jan. 24, 1974	30	Launched Molniya	
Oreol 2	72-107A	Dec. 26, 1973	PL	C-1	680?	1,995	407	74	[1] 109.2			Geophysics	French Auréole 2, science.
Kosmos 626	73-108A	Dec. 29, 1973	TT	F-1m	4,540?	280	257	65	[1] 89.7			Radar ocean surveillance	Moved to higher orbit Feb. 11, 1974.
						990	910	64.9	[2] 104.0				
Kosmos 627	73-109A	Dec. 29, 1973	PL	C-1	680?	1,032	991	83	[1] 105			Navigation	2d Gen. "A".
Kosmos 628	74-1A	Jan. 17, 1974	PL	C-1	680?	1,026	975	83	[1] 105			Navigation	2d Gen. "A".
Kosmos 629	74-3A	Jan. 24, 1974	PL	A-2	5,900?	315	202	62.8	[1] 89.9	Feb. 5, 1974	12	Military photo	Recovered.
Pickaback	74-3D				200?	315	202	62.8	[2] 89.9	Feb. 9, 1974	16		
Kosmos 630	74-4A	Jan. 30, 1974	PL	A-2	6,300?	367	213	72.9	[1] 90	Feb. 13, 1974	14	Military photo	Recovered.
Kosmos 631	74-5A	Feb 6, 1974	PL	C-1	875?	565	522	74	[1] 95.3	Oct. 3, 1980	2,431	Elint ferret	
Kosmos 632	74-6A	Feb. 12, 1974	TT	A-2	6,300?	333	184	65	[1] 89.4	Feb. 26, 1974	14	Military photo	Recovered.
Kosmos 633	74-10A	Feb. 27, 1974	PL	B-1	325?	516	280	71	[1] 92.2	Oct. 4, 1974	219	Radar calibration	
Meteor 1-16	74-11A	Mar. 5, 1974	PL	A-1	3,300?	906	853	81.2	[1] 102.2			Meteorology	
Kosmos 634	74-12A	Mar. 5, 1974	PL	B-1	325?	516	281	71	[1] 92.2	Oct. 9, 1974	218	Radar calibration	
Kosmos 635	74-14A	Mar. 14,1974	PL	A-2	5,900?	350	212	72.9	[1] 89.8	Mar. 26, 1974	12	Military photo	Recovered.

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Pickaback	74–14E				200?,	319	203	72.8	[2] 89.7	Apr. 7, 1974	24		Science.
Kosmos 636	74–16A	Mar. 20, 1974	TT	A–2	6,300?	409	174	65	[1] 90	Apr. 3, 1974	14	Military photo	Recovered.
Kosmos 637	74–17A	Mar. 26, 1974	TT	D–1E	1,750?	35,600	35,600	0.25	[1] 1,426			Vehicle test	Geosynchronous communications.
Tyazheliy Sputnik	74–17B				18,000?	191	166	51.5	[2] 88.0	Mar. 27, 1974	1	Launched Kosmos 637	
Kosmos 638	74–18A	Apr. 3, 1974	TT	A–2	6,800?	325	195	51.8	[1] 89.4	Apr. 13, 1974	10	Man precursor	ASTP Soyuz test, recovered.
						274	258		[2] 89.8				
Kosmos 639	74–19A	Apr. 4, 1974	PL	A–2	6,300?	238	209	81.3	[1] 89	Apr. 15, 1974	11	Military photo	Recovered.
Kosmos 640	74–21A	Apr. 11, 1974	PL	A–2	5,700?	236	205	81.3	[1] 88.9	Apr. 23, 1974	12	Military photo	Recovered.
Molniya 1–27	74–23A	Apr. 20, 1974	PL	A–2e	1,750?	40,713	646	62.9	[1] 738			Communications	
Tyazheliy Sputnik	74–23C				6,000?	625	217	62.8	[2] 93.0	July 4, 1974	74	Launched Molniya	
Kosmos 641–648	72–24A–H	Apr. 23, 1974	PL	C–1	50?	1,508	1385	74	[1] 114.5			Tactical comunications octuple launcher.	
Meteor 1–17	74–25A	Apr. 24, 1974	PL	A–1	3,300?	907	877	81.2	[1] 102.6			Meteorology	
Molniya 2–9	74–26A	Apr. 26, 1974	PL	A–2e	1,800?	40,850	463	62.9	[1] 737			Communications	
Tyazheliy Sputnik	74–26B				6,000?	428	217	62.9	[2] 91.0	May 21, 1974	25	Launched Molniya	
Kosmos 649	74–27A	Apr. 29, 1974	PL	A–2	6,300?	320	189	62.8	[1] 89.3	May 11, 1974	12	Military photo	Recovered.
Kosmos 650	74–28A	Apr. 29, 1974	PL	C–1	600?	1,413	1380	74	[1] 113.5			Geodetic	
Kosmos 651	74–29A	May 15, 1974	TT	F–1m	4540?	276	256	65	[1] 89.6			Radar ocean surveillance	Moved to higher orbit July 25, 1974.
						954	892	65.0	[2] 103.5				
Kosmos 652	74–30A	May 15, 1974	TT	A–2	6,300?	362	180	51.8	[1] 89.6	May 23, 1974	8	Military photo	Recovered.
Kosmos 653	74–31A	May 15, 1974	PL	A–2	5,700?	309	196	62.8	[1] 89.3	May 27, 1974	12	Military photo	Recovered.
Kosmos 654	74–32A	May 17, 1974	TT	F–1m	4,540?	277	261	65	[1] 89.7			Radar ocean surveillance	Moved to higher obit July 30, 1974.
						1,024	913	65.0	[2] 104.4				
Interkosmos II	74–34A	May 17, 1974	KY	C–1	350?	526	484	50.7	[1] 94.5			Geophysics	Solar UV and X-ray, also magnetosphere interactions.
Kosmos 655	74–35A	May 21, 1974	PL	C–1	875?	549	520	74	[1] 95.2	Nov. 19, 1980	2,374	Elint ferret	
Kosmos 656	74–36A	May 27, 1974	TT	A–2	6,570?	354	194	51.6	[1] 89.7	May 29, 1974	2	Man precursor	Soyuz test, ferry version.
Luna 22	74–37A	May 29, 1974	TT	D–1e	5,600	221	219	14.6	[2] 130			Moon	Placed in Luna orbit June 2, 1974
						244	25	14.6	[2] 121				
						1,578	30	21	[2] 142				
Tyazheliy Sputnik	74–37C				18.000	227	178	51.6	[2] 88.5	June 2, 1974	4	Launched Luna 22	
Kosmos 657	74–38A	May 30, 1974	PL	A–2	6,300?	317	182	62.8	[1] 89.2	June 13, 1974	14	Military photo	Recovered.
Kosmos 658	74–41A	June 6, 1974	TT	A–2	5,700?	304	206	65	[1] 89.4	June 18, 1974	12	Military photo	Recovered.
Kosmos 659	74–43A	June 13, 1974	PL	A–2	6,300?	360	190	62.8	[1] 89.7	June 26, 1974	13	Military photo	Recovered.
Kosmos 660	74–44A	June 18, 1974	PL	C–1	650?	1,995	409	83	[1] 109.2			Radar calibration	
Kosmos 661	74–45A	June 21, 1974	PL	C–1	875?	555	513	74	[1] 95	Aug. 27, 1980	2,259	Elint ferret	
Salyut 3	74–46A	June 24, 1974	TT	D–1	18,600	270	219	51.6	[1] 89.1	Aug. 24, 1975	214	Manned station	Military version.
						292	256	51.6	[2] 89.9				
Kosmos 662	74–47A	June 26, 1974	PL	B–1	300?	838	282	71	[1] 95.5	Aug. 28, 1976	794	Radar calibration	
Kosmos 663	74–48A	June 27, 1974	PL	C–1	680?	1,017	983	83	[1] 105			Navigation	2d Gen. "A".
Kosmos 664	74–49A	June 29, 1974	PL	A–2	5,900?	364	212	72.9	[1] 90	July 11, 1974	12	Military photo	Recovered, Mapping Geodesy, resources.

Pickaback	74-49A				200?	277	190	72.9	[2] 89.2	July 13, 1974	14		
Kosmos 665	74-50A	June 29, 1974	PL	A-2e	1,800?	39,384	633	62.9	[1] 71.0			Early warning	
Tyazheliy Sputnik	74-50B				6,000?	610	216	62.8	[2] 92.8	Sept. 1, 1974	64	Launched Kosmos 665	
Soyuz 14	74-51A	July 3, 1974	TT	A-2	6,570?	217	195	51.6	[2] 88.6	July 19, 1974	16	Manned	Popovich, Artyukin recovered, docked with Soyuz 13.
						277	255	51.6	[1] 89.7				
Meteor 1-18	74-52A	July 9, 1974	PL	A-1	3,300?	905	877	81.2	[1] 102.6			Meteorology	Also natural resources.
Kosmos 666	74-53A	July 12, 1974	PL	A-2	6,300?	351	191	62.8	[1] 89.6	July 25, 1974	13	Military photo	Recovered.
Molniya 2-10	74-56A	July 23, 1974	PL	A-2e	1,800?	40,900	460	62.8	[1] 737			Communications	
Tyazheliy Sputnik	74-56C				6,000?	451	216	62.8	[2] 91.2	Aug. 28, 1974	37	Launched Molniya	
Kosmos 667	74-57A	July 25, 1974	TT	A-2	6,300?	342	182	65	[1] 89.5	Aug. 7, 1974	13	Military photo	Recovered.
Kosmos 668	74-58A	July 25, 1974	PL	B-1	325?	519	281	71	[1] 92.2	Feb. 21, 1975	211	Radar calibration	
Kosmos 669	74-59A	July 26, 1974	PL	A-2	5,900?	244	210	81.3	[1] 88.9	Aug. 8, 1974	13	Military photo	Recovered.
Pickaback	74-59G				200?	225	201	81.3	[2] 88.8	Aug. 11, 1974	16		Science, helium-cooled sensors.
Molniya 1-S	74-60A	July 29, 1974	TT	D-1e	1,750?	35,850	35,850	.07	[1] 1,439			Communications	Geosynchronocus.
Tyazheliy Sputnik	74-60B				18,000?	195	183	51.5	[2] 88.2	Aug. 1, 1974	3	Launched Molniya	
Kosmos 670	74-61A	Aug. 6, 1974	TT	A-2	6,800?	307	217	50.6	[1] 89.5	Aug. 9, 1974	3	Man precursor	New variant of Soyuz.
Kosmos 671	74-62A	Aug. 7, 1974	PL	A-2	6,300?	369	191	62.8	[1] 89.7	Aug. 20, 1974	13	Military photo	Recovered.
Kosmos 672	74-64A	Aug. 12, 1974	TT	A-2	6,800?	239	198	51.8	[1] 88.6	Aug. 18, 1974	6	Man precursor	ASTP Soyuz test.
						238	227	51.8	[2] 89.1				
Kosmos 673	74-66A	Aug. 16, 1974	PL	A-1	3,800?	648	620	81.2	[1] 97			Elint ferret	
Soyuz 15	74-67A	Aug. 26, 1974	TT	A-2	6,570?	236	173	51.6	[2] 88.5	Aug. 28, 1974	2	Manned	Sarafanov, Demin failed to dock with Salyut 13.
						275	254	51.6	[1] 89.6				
Kosmos 674	74-68A	Aug. 29, 1974	TT	A-2	6,300?	343	182	65	[1] 89.5	Sept. 7, 1974	9	Military photo	Recovered.
Kosmos 675	74-69A	Aug. 29, 1974	PL	C-1	600?	1,429	1,370	74	[1] 113.7			Geodetic	
Kosmos 676	74-71A	Sept. 11, 1974	PL	C-1	750?	840	799	74	[1] 101			Store-dump communications.	
Kosmos 677-684	74-72A-H	Sept. 19, 1974	PL	C-1	50?	1,519	1,451	74	[1] 115.5			Tactical communications octuple launch.	
Kosmos 685	74-73A	Sept. 20, 1974	TT	A-2	5,700?	303	208	65	[1] 89.4	Oct. 2, 1974	12	Military photo	Recovered.
Kosmos 686	74-74A	Sept. 26, 1974	PL	B-1	325?	515	281	71	[1] 92.2	May 1, 1975	217	Radar calibration	Carrier rocket exploded.
Kosmos 687	74-76A	Oct. 11, 1974	PL	C-1	900?	717	242	74	[1] 94.5	Feb. 5, 1978	1,213	Radar calibration	
Kosmos 688	74-78A	Oct. 18, 1974	PL	A-2	6,300?	371	188	62.8	[1] 89.8	Oct. 30, 1974	12	Military photo	Recovered.
Kosmos 689	74-79A	Oct. 18, 1974	PL	C-1	680?	1,032	992	83	[1] 105.1			Navigation	2n Gen. "A".
Kosmos 690	74-80A	Oct. 22, 1974	PL	A-2	5,500?	389	223	62.8	[1] 90.4	Nov. 12, 1974	21	Biology	Recovered.
Fickaback	74-80E				200?	341	212	62.8	[2] 90.0	Dec. 14, 1974	53		
Molniya 1-28	74-81A	Oct. 24, 1974	PL	A-2e	1,750?	40,617	683	62.8	[1] 736			Communications	
Tyazheliy Sputnik	74-81C				6,000?	658	211	62.8	93.3	Jan. 3, 1975	71	Launched Molniyi	
Kosmos 691	74-82A	Oct. 25, 1974	TT	A-2	6,300?	352	180	65	[1] 89.5	Nov. 6, 1974	12	Military photo	Recovered.
Meteor 1-19	74-83A	Oct. 28, 1974	PL	A-1	3,300?	917	855	81.2	[1] 102.5			Meteorology	
Luna 23	74-84A	Oct. 28, 1974	TT	D-1e	5,600?	104	94	138	[2] 117	Nov. 6, 1974	9	Moon	Orbited Moon, landed at 13.5N 56.5E to drill for soil sample.
						105	11	138	[2] 114				
Tyazheliy Sputnik	74-84B				18,000?	246	183	51.5	[2] 88.7	Nov. 1, 1974	3	Launched Luna 23	
Sample returner	74-34E				470?								Failed to launch because drill damaged.
Interkosmos 12	74-86A	Oct. 31, 1974	PL	C-1	350?	708	264	74.1	[1] 94.1	July 11, 1975	253	Geophysics	Atmospheric and ionospheric studies, micrometeorites.
Kosmos 692	74-87A	Nov. 1, 1974	PL	A-2	5,900?	315	201	62.8	[1] 89.4	Nov. 13, 1974	12	Military photo	Recovered.
Pickaback	74-87F				200?	295	197	62.8	[2] 89.4	Nov. 23, 1974	22		

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 693	74-88A	Nov. 4, 1974	PL	A-2	5,900?	271	215	81.3	[1]89.1	Nov. 16, 1974	12	Military photo	Recovered, Mapping, geodesy, resources.
Pickaback	74-88E				200?	215	182	81.5	[2]88.5	Nov. 17, 1974	13		
Kosmos 694	74-90A	Nov. 16, 1974	PL	A-2	6,300?	344	213	72.9	[1]89.8	Nov. 29, 1974	13	Military photo	Recovered.
Kosmos 695	74-91A	Nov. 20, 1974	PL	B-1	325?	493	283	71	[1]92	July 15, 1975	237	Radar calibration	
Molniya 3-1	74-92A	Nov. 21, 1974	PL	A-2e	1,890?	40,690	650	62.8	[1] 732			Communications	Especially designed for color TV.
Tyazheliy Sputnik	74-92C				6,000?	626	201	62.8	[2] 92.8	Jan. 11, 1975	51	Launched Molniya	
Kosmos 696	74-95A	Nov. 27, 1974	PL	A-2	5,700?	345	212	72.9	[1] 89.8	Dec. 9, 1974	12	Military photo	Recovered.
Soyuz 16	74-96A	Dec. 2, 1974	TT	A-2	6,680?	291	184	51.8	[2] 89.2	Dec. 8, 1974	6	Manned	Filipchenko, Rukavishnikov, recovered ASTP test.
						223	177	51.8	[1] 88.4				
						225	225	51.8	[2] 55.9				
Kosmos 697	74-98A	Dec. 13, 1974	PL	A-2	6,700?	415	182	62.8	[1] 90.2	Dec. 25, 1974	12	Military photo	Recovered, first 4th Generation with solar panels, integral maneuver capability?
Meteor 1-20	74-99A	Dec. 17, 1974	PL	A-1	3,300?	910	861	81.2	[1] 102.4			Meteorology	
Kosmos 698	74-100A	Dec. 18, 1974	PL	C-1	875?	566	515	74	[1] 95.3	Dec. 9, 1980	2,183	Elint ferret	
Molniya 2-11	74-102A	Dec. 21, 1974	PL	A-2e	1,800?	40,675	641	62.9	[1] 737			Communications	
Tyazheliy Sputnik	74-102C				6,000?	626	211	62.8	[2] 92.9	Mar. 8, 1975	77	Launched Molniya	
Kosmos 699	74-103A	Dec. 24, 1974	TT	F-1m	4,150?	454	436	65	[1] 93.2	Oct. 16, 1977	1,027	Elint ocean surveillance	Exploded at end of mission, used ion propulsion.
Salyut 4	74-104A	Dec. 26, 1974	TT	D-1	18,600?	270	219	51.6	[1] 89.1	Feb. 2, 1977	770	Manned station	Civilian version.
						355	343	51.6	[2] 91.3				
Kosmos 700	74-105A	Dec. 26, 1974	PL	C-1	680?	1,012	976	83	[1] 105			Navigation	3d Gen. "B".
Kosmos 701	74-106A	Dec. 27, 1974	TT	A-2	6,300?	339	210	71.4	[1] 89.8	Jan. 9, 1975	13	Military photo	Recovered.
Soyuz 17	75-1A	Jan. 10, 1975	TT	A-2	6,570?	260	190	51.6	[2] 90.7	Feb. 9, 1975	30	Manned	Gubarev, Grechko docked with Salyut 4, recovered.
						355	342	51.6	[1] 91.3				
Kosmos 702	75-2A	Jan. 17, 1975	TT	A-2	5,700?	334	210	71.4	[1] 89.7	Jan. 29, 1975	12	Military photo	Recovered.
Kosmos 703	75-3A	Jan. 21, 1975	PL	B-1	250?	1,545	207	82	[1] 102	Nov. 20, 1975	303	Radar calibration	
Kosmos 704	75-5A	Jan. 23, 1975	PL	A-2	6,300?	329	213	72.9	[1] 89.6	Feb. 6, 1975	14	Military photo	Recovered.
Kosmos 705	75-6A	Jan. 28, 1975	PL	B-1	325?	524	281	71	[1] 92.3	Nov. 18, 1975	294	Radar calibration	
Kosmos 706	75-7A	Jan. 30, 1975	PL	A-2e	1,800?	39,812	625	62.8	[1] 719			Early warning	
Tyazheliy Sputnik	75-7C				6,000?	629	179	62.9	[2] 92.6	Mar. 2, 1975	30	Launched Kosmos 706	
Kosmos 707	75-8A	Feb. 5, 1975	PL	C-1	875?	550	505	74	[1] 95.2	Sept. 7, 1980	2,041	Elint ferret	
Molniya 2-12	75-9A	Feb. 6, 1975	PL	A-2e	1,800?	40,685	640	62.8	[1] 737			Communications	
Tyazheliy Sputnik	75-9C				6,000?	620	212	62.8	[2] 92.9	Apr. 23, 1975	76	Launched Molniya	
Kosmos 708	75-12A	Feb. 12, 1975	PL	C-1	600?	1,423	1,387	69.2	[1] 113.6			Geodetic	
Kosmos 709	75-13A	Feb. 12, 1975	PL	A-2	6,300?	333	188	62.8	[1] 89.4	Feb. 25, 1975	13	Military photo	Recovered.
Kosmos 710	75-15A	Feb. 26, 1975	TT	A-2	6,300?	355	180	65	[1] 89.6	Mar. 12, 1975	14	Military photo	Recovered.
Kosmos 711-718	75-16A-H	Feb. 28, 1975	PL	C-1	50?	1,530	1,449	74	[1] 115.5			Tactical communications octuple launch.	
Kosmos 719	75-18A	Mar. 12, 1975	TT	A-2	6,300?	329	182	65	[1] 89.3	Mar. 25, 1975	13	Military photo	Recovered.

Kosmos 720	75–19A	Mar. 21, 1975	PL	A–2	5,900?	283	223	62.8	[1] 89.4	Apr. 1, 1975	12	Military photo	Recovered. Mapping, geodesy, resources.
Pickaback	75–19F				200?	258	206	62.8	[2] 89.1	Apr. 5, 1975	15		
Kosmos 721	75–20A	Mar. 26, 1975	PL	A–2	5,900?	241	210	81.3	[1] 88.9	Apr. 7, 1975	12	Military photo	Recovered.
Pickaback	75–20F				200?	198	177	81.3	[2] 88.3	Apr. 10, 1975	15		
Kosmos 722	75–21A	Mar. 27, 1975	TT	A–2	6,300?	359	210	71.4	[1] 89.9	Apr. 9, 1975	13	Military photo	Recovered.
Interkosmos 13	75–22A	Mar. 27, 1975	PL	C–1	350	1,714	296	83	[1] 104.9	Sept. 2, 1980	1,986	Geophysics	Magnetosphere and polar ionosphere.
Meteor I–21	75–23A	Apr. 1, 1975	PL	A–1	3,300?	906	877	81.2	[1] 102.6			Meteorology	
Kosmos 723	75–24A	Apr. 2, 1975	TT	F–1m	4,540?	277	256	65	[1] 89.6			Radar ocean surveillance	Moved to higher orbit May 15, 1975.
						951	716	65.0	[2] 103.7				
Soyuz		Apr. 5, 1975	TT	A–2	6,570?	200up	1,600 away			Apr. 5, 1975	0	Manned	Lazarev, Makarov, mission aborted before reaching orbit, crew saved.
Kosmos 724	75–25A	Apr. 7, 1975	TT	F–1m	4,540?	276	258	65	[1] 89.7			Radar ocean surveillance	Moved to higher orbit June 11, 1975, 166 MHz, 19.542 MHz.
						998	868	65.5	[2] 103.0				
Kosmos 725	75–26A	Apr. 8, 1975	PL	B–1	325?	508	283	71	[1] 92.1	Jan. 6, 1976	273	Radar calibration	
Kosmos 726	75–28A	Apr. 11, 1975	PL	C–1	680?	1,008	972	83	[1] 104.7			Navigation	3d Gen. "B".
Molniya 3–2	75–29A	Apr. 14, 1975	PL	A–2e	1,890?	40,660	636	63	[1] 736			Communications	
Tyazheliy, Sputnik	75–29C				6,000?	593	196	62.9	[2] 92.4	June 4, 1975	51	Launched Molniya	
Kosmos 727	75–30A	Apr. 16, 1975	TT	A–2	6,300?	358	180	65	[1] 89.6	Apr. 28, 1975	12	Military photo	Recovered.
Kosmos 728	75–31A	Apr. 18, 1975	PL	A–2	5,900?	350	211	72.8	[1] 89.8	Apr. 29, 1975	11	Military photo	Recovered.
Pickaback	75–31G				200?	315	200	72.8	[2] 89.7	May 16, 1975	28		Tested plasma electrojet accelerators.
Ariabat	75–33A	Apr. 19, 1975	KY	C–1	360	619	563	50.7	[1] 96.3			Geophysics	Indian Aryabhata Science.
Kosmos 729	75–34A	Apr. 22, 1975	PL	C–1	680?	1,023	995	83	[1] 105			Navigation	2d Gen. "A".
Kosmos 730	75–35A	Apr. 24, 1975	PL	A–2	6,300?	251	212	81.3	[1] 89	May 6, 1975	12	Military photo	Recovered.
Molniya I–29	75–36A	Apr. 29, 1975	PL	A–2e	1,750?	40,848	468	63	[1] 737			Communications	
Tyazheliy Sputnik	75–36C				6,000?	459	210	628	[2] 91.2	June 3, 1975	35	Launched Molniya	
Kosmos 731	75–41A	May 21, 1975	TT	A–2	5,900?	313	207	65	[1] 89.5	June 2, 1975	12	Military photo	Recovered.
Pickaback	75–41H				200?	286	199	65.0	[2] 89.4	June 19, 1975	29		
Soyuz 18	75–44A	May 24, 1975	TT	A–2	6,570?	247	193	51.6	[1] 88.6	July 26, 1975	63	Manned	Klimuk, Sevastyanov docked with Salyut 4, recovered.
						356	344	51.6	[2] 91.3				
Kosmos 732–739	75–45A–H	May 28, 1975	PL	C–1	50?	1,532	1,475	74	[1] 115.8			Tactical communications octuple launch.	
Kosmos 740	75–46A	May 28, 1975	TT	A–2	6,300?	347	181	65	[1] 89.5	June 10, 1975	13	Military photo	Recovered.
Kosmos 741	75–47A	May 30, 1975	PL	A–2	5,700?	246	210	81.4	[1] 89.0	June 11, 1975	12	Military photo	Recovered.
Kosmos 742	75–48A	June 3, 1973	PL	A–2	6,300?	375	189	62.8	[1] 89.8	June 15, 1975	12	Military photo	Recovered.
Interkosmos		June 4, 1975	KY	C–1	350?					June 4, 1975	0	Geophysics	Failed to reach orbit.
Molniya 1–30	75–49A	June 5, 1975	PL	A–2e	1,750?	40,890	450	63	[1] 737			Communications	
MAS 2	75–49B					40,890	450	63	[2] 737				French SRET No. #2 Solar cell tests.
Tyazheliy Sputnik	75–49c				6,000?	424	213	62.8	[2] 90.9	July 16, 1975	41,	Launched Molniya	
Venera 9	75–50A	June 8, 1975	TT	D–1e	4,936	1.11au	.7au	.23	[2] [5]316			Venus	Orbited Venus Oct. 22, 1975. (Orbital elements at Venus in parentheses.)
						(112,200)	(1,510)	(34.1)	[2] (2,898)				
Tyazheliy Sputnik	75–50C				18,000?	196	171	51.5	[2] 88.1	June 9, 1975	1	Launched Venera No. 9	
						171							
Lander	75–50D				1,560					Oct. 22, 1975	136		Soft landed, returned picture.
Kosmos 743	75–53A	June 12, 1975	PL	A–2	6,300?	355	190	62.8	[1] 89.6	June 25, 1975	8	Military photo	Recovered.

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Venera 10	75-54A	June 14, 1975	TT	D-1e	5,033	1.11au	.7au	.23	[2] [5] 316			Venus	Orbited Venus Oct. 25, 1975. (Orbital elements at Venus in parentheses.)
						(113,900)	(1,620)	(29.5)	[2] (2,963)				
Tyazheliy Sputnik	75-54C				18,000?	206	162	51.5	[2] 88.1	June 15, 1975	1	Landed Venera No. 10	
Lander	75-54D				1,560					Oct. 25, 1975	133		Soft landed, returned picture.
Kosmos 744	75-56A	June 20, 1975	PL	A-1	3,800?	650	612	81.2	[1] 97.1			Elint ferret	
Kosmos 745	75-58A	June 24, 1975	PL	B-1	325?	540	274	71	[1] 92.4	Mar. 12, 1976	262	Radar calibration	
Kosmos 746	75-59A	June 25, 1975	PL	A-2	6,300?	346	188	62.8	[1] 89.5	July 8, 1975	13	Military photo	Recovered.
Kosmos 747	75-60A	June 27, 1975	PL	A-2	5,900?	309	197	62.8	[1] 89.3	July 9, 1975	12	Military photo	Recovered.
Pickaback	75-60F				200?	254	185	62.8	[2] 88.9	July 17, 1975	20		
Kosmos 748	75-61A	July 3, 1975	PL	A-2	6,300?	339	184	62.8	[1] 89.5	July 16, 1975	13	Military photo	Recovered.
Kosmos 749	75-62A	July 4, 1975	PL	C-1	875?	557	511	74	[1] 95.3	Sept. 26, 1980	1,911	Elint ferrett	
Molniya 2-13	75-63A	July 8, 1975	PL	A-2e	1,800?	40,864	465	62.8	[1] 737			Communications	
Tyazheliy Sputnik	75-63C				6,000?	445	204	62.8	[2] 91.0	Aug. 9, 1975	32	Launched Molniya	
Meteor 2-1	75-64A	July 11, 1975	PL	A-1	3,300?	903	872	81.3	[1] 102.5			Meteorology	
Soyuz 19	75-65A	July 15, 1975	TT	A-2	6,800	220	186	51.8	[2] 88.5	July 21, 1975	6	Manned	Leonov, Kubasov docked with Apollo (Stafford, Brand, Slayton), recovered (ASTP).
						225	223	51.8	[1] 88.9				
Kosmos 750	75-67A	July 17, 1975	PL	B-1	300?	830	281	71	[1] 95.4	Sept. 29, 1977	489	Radar calibration	
Kosmos 751	75-68A	July 23, 1975	PL	A-2	5,700?	335	203	62.8	[1] 89.6	Aug. 4, 1975	12	Military photo	Recovered.
Kosmos 752	75-69A	July 24, 1975	PL	C-1	900?	526	480	65.9	[1] 94.6	Feb. 28, 1981	2,046	Radar calibration	
Kosmos 753	75-71A	July 31, 1975	PL	A-2	6,300?	351	189	62.8	[1] 89.6	Aug. 13, 1975	13	Military photo	Recovered.
Kosmos 754	75-73A	Aug. 13, 1975	TT	A-2	6,300?	345	210	71.4	[1] 89.8	Aug. 26, 1975	13	Military photo	Recovered.
Kosmos 755	75-74A	Aug. 14, 1975	PL	C-1	680?	1,025	991	82.9	[1] 105			Navigation	3d Gen. "B".
Kosmos 756	75-76A	Aug. 22, 1975	PL	A-1	3,800?	649	627	81.2	[1] 97.3			Elint ferret	
Kosmos 757	75-78A	Aug. 27, 1975	PL	A-2	6,300?	337	190	62.8	[1] 89.5	Sept. 9, 1975	13	Military photo	Recovered.
Vertikal 3		Sept. 2, 1975	KY	SS-3	1,300?	502UP			[2]	Sept 2, 1975	0	Geophysical probe	Interkosmos.
Molniya 1-31	75-79A	Sept. 2, 1975	PL	A-2e	1,750?	40,681	639	62.8	[1] 737			Communications	
Tyazhely Sputnik	75-79C				6,000?	613	206	62.8	[2] 928	Nov. 1, 1975	60	Launched Molniya	
Kosmos 758	75-80A	Sept. 5, 1975	PL	A-2	6,700?	351	181	67.2	[1] 89.5	Sept. 25, 1975	20	Military photo	Expoloded during mission. Probably used solar panels.
						579	195	67.3	[2] 92.3				
Molniya 2-14	75-81A	Sept. 9, 1975	PL	A-2e	1,800?	40,836	470	62.8	[1] 736			Communications	
Tyazheliy Sputnik	75-81C				6,000?	459	213	62.8	[2] 91.2	Oct. 18, 1975	39	Launched Molniya	
Kosmos 759	75-84A	Sept. 12, 1975	PL	A-2	5,900?	281	234	62.8	[1] 89.6	Sept. 23, 1975	12	Military photo	Recovered, mapping geodesy, resources.
Pickaback	75-84F				200?	264	221	62.8	[2] 89.6	Sept. 26, 1975	14		
Kosmos 760	75-85A	Sept. 16, 1975	TT	A-2	6,300?	355	181	65	[1] 90.6	Sept. 30, 1975	14	Military photo	Recovered.
Kosmos 761-768	75-86A-H	Sept. 17, 1975	PL	C-1	50?	1,537	1,454	74	[1] 115.5			Tactical communications octuple launch.	
Meteor 1-22	75-87A	Sept. 18, 1975	PL	A-1	3,300?	918	867	81.2	[1] 102.3			Meteorology	
Kosmos 769	75-88A	Sept. 23, 1975	PL	A-2	5,900?	331	211	72.9	[1] 89.6	Oct. 5, 1975	12	Military photo	Recovered.
Pickaback	75-88L				200?	297	199	72.8	[2] 89.5	Oct. 13, 1975	20		
Kosmos 770	75-89A	Sept. 24, 1975	PL	C-1	600?	1,222	1,188	83	[1] 109.2			Geodetic	

Kosmos 771	75–90A	Sept. 25, 1975	PL	A–2	6,300?	247	219	81.3	[1] 88.9	Oct. 8, 1975	13	Military photo	Recovered, also Earth resources.
Kosmos 772	75–93A	Sept. 29, 1975	TT	A–2	6,800?	320	201	51.8	[1] 89.4	Oct. 2, 1975	3	Man precursor	Improved Soyuz variant, recovered. Systems cest.
Kosmos 773	75–94A	Sept. 30, 1975	PL	C–1	750?	828	791	74.1	[1] 100.9			Store-dump communications	
Kosmos 774	75–95A	Oct. 1, 1975	TT	A–2	6,300?	333	212	71.4	[1] 89.7	Oct. 15, 1975	14	Military photo	Recovered.
Kosmos 775	75–97A	Oct. 8, 1975	TT	D–1e	1,800?	35,900	35,900	0.1	[1] 1,442			Early warning	Geosynchronous.
Tyazheliy Sputnik	75–97B				18,000?	205	178	51.5	[2] 88.3	Oct. 10, 1975	2	Launched Kosmos 775	
Kosmos 776	75–101A	Oct. 17, 1975	PL	A–2	5,900?	310	203	62.8	[1] 89.4	Oct. 29, 1975	12	Military photo	Recovered.
Pickaback	75–101D				200?	274	195	62.8	[2] 89.2	Nov. 1, 1975	15		
Kosmos 777	75–102A	Oct. 29, 1975	TT	F–1m	4,150?	456	437	65	[1] 93.3	June 3, 1976	218	Elint ocean surveillance	Ion propulsion, later exploded.
Kosmos 778	75–103A	Nov. 4, 1975	PL	C–1	680?	1,018	989	83	104.9			Navigation	3d Gen. "B".
Kosmos 779	75–104A	Nov. 4, 1975	PL	A–2	6,300?	334	188	62.8	[1] 89.4	Nov. 18, 1975	14	Military photo	Recovered.
Molniya 3–3	75–105A	Nov. 14, 1975	PL	A–2e	1,890?	40,930	470	62.4	[1] 736			Communications	
Tyazheliy Sputnik	75–105C				6,000?	451	191	62.8	[2] 90.9	Dec. 5, 1975	21	Launched Molniya	
Soyuz 20	75–106A	Nov. 17, 1975	TT	A–2	6,570?	264	200	51.6	[1] 88.8	Feb. 16, 1976	91	Unmanned	Docket with Salyut 4, recovered. Systems cest.
						367	343	51.6	[2] 91.4				
Kosmos 780	75–108A	Nov. 21, 1975	TT	A–2	5,900?	298	206	65	[1] 89.3	Dec. 3, 1975	12	Military photo	Recovered.
Pickaback	75–108D				200?	268	197	65.0	[2] 89.1	Dec. 11, 1975	20		
Kosmos 781	75–109A	Nov. 21, 1975	PL	C–1	875?	557	508	74	[1] 95.2	Nov. 26, 1980	1,832	Elint ferret	
Kosmos 782	75–110A	Nov. 25, 1975	PL	A–2	5,500?	405	227	62.8	[1] 90.5	Dec. 15, 1975	22	Biology	Recovered.
Pickaback	75–110D				200?	369	216	62.8	[2] 90.4	Feb. 10, 1976	77		
Kosmos 783	75–112A	Nov. 28, 1975	PL	C–1	750?	838	797	74	[1] 101			Store-dump communications	
Kosmos 784	75–113A	Dec. 3, 1975	PL	A–2	5,900?	252	216	81.3	[1] 89	Dec. 15, 1975	12	Military photo	Recovered.
Pickaback	75–113G				200?	217	203	81.3	[2] 88.7	Dec. 21, 1975	18		
Interkosmos 14	75–115A	Dec. 11, 1975	PL	C–1	372	1,707	345	74	[1] 105.3			Geophysics	
Kosmos 785	75–116A	Dec. 12, 1975	TT	F–1m	4,540?	278	259	65	[1] 89.7			Radar ocean surveillance	Moved to higher orbit first day (Dec. 12, 1975).
						1,023	898	65.1	[2] 104.3				
Kosmos 786	75–120A	Dec. 16, 1975	TT	A–2	6,300?	347	180	65	[1] 89.5	Dec. 29, 1975	13	Military photo	Recovered.
Molniya 2–15	75–121A	Dec. 17, 1975	PL	A–2e	1,800?	40,836	451	62.8	[1] 736			Communications	
Tyazheliy Sputnik	75–121C				6,000?	433	196	62.8	[2] 90.8	Jan. 11, 1976	25	Launched Molniya	
Prognoz 4	75–122A	Dec. 22, 1975	TT	A–2e	905	199,000	634	65	[1] 5740			Geophysics	Solar wind and magnetosphere.
Tyazheliy Sputnik	75–122C				6,000?	498	209	65.0	[2] 91.6	Feb. 9, 1976	49	Launched Prognoz	
Raduga 1	75–123A	Dec. 22, 1975	TT	D–1e	2,500?	35,800	35,800	0.3	[1] 1,434			Communicationis	Geosynchronous at Statsionar #1 position.
Tyazheliy Sputnik	75–123B				18,000?	197	146	51.5	[2] 87.9	Dec. 22, 1975	0	Launched Raduga	
Meteor 1–23	75–124A	Dec. 25, 1975	PL	A–1	3,300?	913	857	81.3	[1] 102.4			Meteorology	
Molniya 3–4	75–125A	Dec. 27, 1975	PL	A–2e	1,890?	40,800	470	62.8	[1] 736			Communications	
Tyazheliy Sputnik	75–125C				6,000?	449	194	62.8	[2] 90.9	Jan. 19, 1976	23	Launched Molniya	
Kosmos 787	76–1A	Jan. 6, 1976	PL	C–1	875?	564	519	74	[1] 95.3	Dec. 12, 1980	1,802	Elint ferret	
Kosmos 788	76–2A	Jan. 7, 1976	PL	A–2	6,300?	343	191	62.8	[1] 89.5	Jan. 20, 1976	13	Military photo	Recovered.
Kosmos 789	76–5A	Jan. 20, 1976	PL	C–1	680?	1,029	993	83	[1] 105			Navigation	3d Gen. "B".
Molniya 1–32	76–6A	Jan. 22, 1976	TT	A–2e	1,750?	38,934	491	62.5	[1] 698			Communications	
Tyazheliy Sputnik	76–6C				6,000?	493	240	63.0	[2] 91.9	Apr. 19, 1976	88	Launched Molniya	
Kosmos 790	76–7A	Jan. 23, 1976	PL	C–1	875?	559	513	74	[1] 95.2	Nov. 12, 1980	1,755	Elint ferret	
Kosmos 791–798	76–8A–H	Jan. 28, 1976	PL	C–1	50?	1,538	1,453	74	[1] 115.6			Tactical communications octuple launch.	

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 799	76–9A	Jan. 29, 1976	TT	A–2	5,700?	328	210	71.4	[1] 89.6	Feb. 10, 1976	12	Military photo	Recovered.
Kosmos 800	76–11A	Feb. 3, 1976	PL	C–1	680?	1,027	1,000	83	[1] 105			Navigation	2d Gen. "A".
Kosmos 801	76–12A	Feb. 5, 1976	PL	B–1	300?	823	279	71	[1] 95.3	Jan. 5, 1978	700	Radar calibration	
Kosmos 802	76–13A	Feb. 11, 1976	TT	A–2	6,300?	355	180	65	[1] 89.6	Feb. 25, 1976	14	Military photo	Recovered.
Kosmos 803	76–14A	Feb. 12, 1976	PL	C–1	750?	624	554	66	[1] 96.4			Target for ASAT	
Kosmos 804	76–15A	Feb. 16, 1976	TT	F–1m	3,320?	698	149	65.1	[1] 92.8	Feb. 16, 1976	0	ASAT	Passed near Kosmos 803, then deboosted into Pacific.
						615	556	65.9	[2] 96.4				
Kosmos 805	76–18A	Feb. 20, 1976	PL	A–2	6,700?	372	181	67.2	[1] 89.7	Mar. 11, 1976	20	Military photo	Recoverad, solar panels.
Kosmos 806	76–20A	Mar 10, 1976	TT	A–2	6,300?	353	182	71.4	[1] 89.7	Mar. 23, 1976	13	Military photo	Recovered.
Molniya 1–33	76–21A	Mar. 11, 1976	PL	A–2e	1,750?	40,683	518	62.5	[1] 734			Communications	
Tyazheliy Sputnik	76–21B				6,000?	488	203	62.9	[2] 91.4	Apr. 13, 1976	33	Launched Molniya	
Kosmos 807	76–22A	Mar. 12, 1976	PL	C–1	650?	1,985	403	83	[1] 109.1			Radar calibration	
Kosmos 808	76–24A	Mar. 16, 1976	PL	A–1	3,800?	647	618	81.3	[1] 97.1			Elint ferret	
Kosmos 809	76–25A	Mar. 18, 1976	TT	A–2	5,700?	322	210	65	[1] 89.6	Mar. 30, 1976	12	Military photo	Recovered.
Molniya 1–34	76–26A	Mar. 19, 1976	TT	A–2e	1,750?	38,984	494	63	[1] 699			Communications	
Tyazhely Sputnik	76–26C				6,000?	503	220	63.0	[2] 91.8	May 7, 1976	49	Launched Molniya	
Kosmos 810	76–28A	Mar. 26, 1976	PL	A–2	6,300?	358	188	62.8	[1] 89.7	Apr. 8, 1976	13	Military photo	Recovered.
Kosmos 811	76–30A	Mar. 31, 1976	PL	A–2	5,900?	361	212	729	[1] 89.9	Apr. 12, 1976	12	Military photo	Recovered, Mapping, geodesy, resources.
Pickaback	76–30E				200?	318	201	729	[2] 89.7	Apr. 15, 1976	15		
Kosmos 812	76–31A	Apr. 6, 1976	PL	C–1	895?	558	504	741	[1] 95.2	Oct. 30, 1980	1,668	Elint ferret	
Meteor 1–24	76–32A	Apr. 7, 1976	PL	A–1	3,300?	906	863	81.2	[1] 102.3			Meterology	
Kosmos 813	76–33A	Apr. 9, 1976	PL	A–2	5,700?	250	212	81.3	[1] 89	Apr. 21, 1976	12	Military photo	Recovered.
Kosmos 814	76–34A	Apr. 13, 1976	TT	F–1m	3,320?	474	150	65.1	[1] 90.6	Apr. 13, 1976	0	ASAT	Passed near Kosmos 803, then deboosted into Pacific.
Kosmos 815	76–36A	Apr. 28, 1976	PL	A–2	6,300?	254	218	81.3	[1] 89	May 11, 1976	13	Military photo	Recovered.
Kosmos 816	76–37A	Apr. 28, 1976	PL	C–1	900?	525	482	65.9	[1] 94.6	Nov. 24, 1979	1,305	Radar calibration	
Kosmos 817	76–40A	May 4, 1976	TT	A–2	6,300?	347	178	65	[1] 89.5	May 8, 1976	13	Military photo	Recovered.
Molniya 3–5	76–41A	May 12, 1976	PL	A–2e	1,890?	40,660	652	62.8	[1] 736			Communications	
Tyazheliy Sputnik	76–41C				6,000?	632	217	62.8	[2] 93.0	Sept. 8, 1976	119	Launched Molniya	
Meteor 1–25	76–43A	May 15, 1976	PL	A–1	3,300?	908	866	81.2	[1] 102.4			Meterology	Also used for Interkosmos program sciences.
Kosmos 818	76–44A	May 18, 1976	PL	B–1	325?	506	281	71	[1] 92.1	Mar. 7, 1977	293	Radar calibration	
Kosmos 819	76–45A	May 20, 1976	TT	A–2	5,700?	307	204	65	[1] 89.5	Jun. 1, 1976	12	Military photo	Recovered.
Kosmos 820	76–46A	May 21, 1976	PL	A–2	6,300?	236	214	81.4	[1] 88.8	Jun. 2, 1976	12	Military photo	Recovered, also Earth resources.
Kosmos 821	76–48A	May, 26, 1976	PL	A–2	6,300?	338	212	72.8	[1] 89.7	Jun. 8, 1976	13	Military photo	Recovered.
Kosmos 822	76–49A	May 28, 1976	PL	C–1	900?	729	284	74	[1] 94.6	Aug. 8, 1978	802	Radar calibration	
Kosmos 823	76–51A	Jun. 2, 1976	PL	C–1	680?	1,023	996	83	[1] 105			Navigation	2d Gen. "A."
Kosmos 824	76–52A	June 8, 1976	TT	A–2	6,300?	345	209	71.4	[1] 89.8	June 21, 1976	13	Military photo	Recovered.
Kosmos 825–832	76–54A–H	June 15, 1976	PL	C–1	50?	1,530	1,450	74	[1] 115.5			Tactical communications octuple launch.	
Kosmos 833	76–55A	June 16, 1976	PL	A–2	6,300?	335	189	62.8	[1] 89.5	June 29, 1976	13	Military photo	Recovered.

Interkosmos 15	76–56A	June 19, 1976	PL	C–1	422	521	487	74	¹ 94.6	Nov. 18, 1979	1,247	Geophysics	Test of new AUOS—automatic universal orbital station.
Salyut 5	76–57A	June 22, 1976	TT	D–1	18,600?	260 281	219 269	51.6 51.6	¹ 89 ² 89.8	Aug. 8, 1977	412	Manned station	Military version.
Kosmos 834	76–58A	June 24, 1976	PL	A–2	5,700?	263	223	81.4	¹ 89.1	July 6, 1976	12	Military photo	Recovered.
Kosmos 835	76–60A	June 29, 1976	TT	A–2	6,300?	338	180	65	¹ 89.4	July 12, 1976	13	Military photo	Recovered.
Kosmos 836	76–61A	June 29, 1976	PL	C–1	750?	843	796	74	¹ 101			Store-dump communications	
Kosmos 837	76–62A	July 1, 1976	PL	A–2e	1,800?	860	505	62.8	¹ 98.1			Communications	Probable Molniya 2 failure.
Tyazheliy Sputnik	76–62C				6,000?	446	189	62.8	² 90.9	July 21, 1976	20	Launched Kosmos 837	
Kosmos 838	76–63A	July 2, 1976	TT	F–1m	4,150?	456	438	65	¹ 93.3	Aug. 23, 1977	417	Elint ocean surveillance	Ion propulsion, later exploded (June 1977).
Soyuz 21	76–64A	July 6, 1976	TT	A–2	6,570?	253 280	193 254	51.6 51.6	¹ 88.7 ² 89.6	Aug. 24, 1976	49	Manned	Volynov, Zholobov docked with Salyut 5, recovered.
Kosmos 839	76–67A	July 8, 1976	PL	C–1	630?	2,101	984	65.9	¹ 117			Target for ASAT	
Kosmos 840	76–68A	July 14, 1976	PL	A–2	5,700?	343	212	72.9	¹ 89.7	July 26, 1976	12	Military photo	Recovered.
Kosmos 841	76–69A	July 15, 1976	PL	C–1	750?	826	789	74	¹ 101			Store-dump communications	
Kosmos 842	76–70A	July 21, 1976	PL	C–1	600?	1,023	987	83	¹ 105			Geodetic	
Kosmos 843	76–71A	July 21, 1976	TT	F–1m	3,320?	360	149	65.1	¹ 89.4	July 21, 1976	0	ASAT	May have failed to approach Kosmos 839, plunged into Pacific.
Kosmos 844	76–72A	July 22,1976	PL	A–2	6,700?	385	181	67.1	¹ 89.8	Aug. 30, 1976	39	Military photo	Exploded. Probably had solar panels.
Molniya 1–35	76–74A	July 26, 1976	TT	A–2e	1,750?	39,059	499	62.9	¹ 701			Communications	
Tyazheliy Sputnik	76–74C				6,000?	509	215	62.9	² 91.8	Sept. 18,1976	57	Launched Molniya	
Kosmos 845	76–75A	July 27, 1976	PL	C–1	875?	557	505	74	¹ 95.2	Nov. 15, 1980	1,572	Elint ferret	
Interkosmos 16	76–76A	July 27, 1976	KY	C–1	475	523	465	50.6	¹ 94.4	July 10, 1979	1,078	Geophysics	Solar UV and X-ray studies.
Kosmos 846	76–78A	July 29, 1976	PL	C–1	680?	1,025	967	83	¹ 105			Navigation	2d Gen. "A".
Kosmos 847	76–79A	Aug. 4, 1976	PL	A–2	6,300?	342	189	62.8	¹ 89.5	Aug. 17, 1976	13	Military photo	Recovered.
Luna 24	76–81A	Aug. 9, 1976	TT	D–1e	5,600?	115 120	115 12	120 120	² 119 ² 114	Aug. 18, 1976	9	Moon	Orbited Moon, landed at 21.7N 62.2E to drill sample.
Tyazheliy Sputnik	76–81C				18,000?	242	188	51.5	² 88.7	Aug. 15, 1976	6	Launched Luna 24	
Sample returner	76–81E	Aug. 19, 1976	Moon		470?					Aug. 22, 1976	3		Recovered in U.S.S.R.
Kosmos 848	76–82A	Aug. 12, 1976	PL	A–2	5,900?	325	214	62.8	¹ 89.6	Aug. 25, 1976	13	Military photo	Recovered.
Pickaback	76–82C				200?	304	206	62.8	² 89.6	Aug. 17, 1976	5		
Kosmos 849	76–83A	Aug. 18, 1976	PL	B–1	300?	889	276	71	¹ 96	Apr. 24, 1978	614	Radar calibration	
Kosmos 850	76–84A	Aug. 26, 1976	PL	B–1	325?	518	280	71	¹ 92	May 16, 1977	263	Radar calibration	
Kosmos 851	76–85A	Aug. 27, 1976	PL	A–1	3,800?	649	592	81	¹ 96.2			Elint ferret	
Kosmos 852	76–86A	Aug. 28, 1976	TT	A–2	6,300?	354	179	65	¹ 89.5	Sept. 10, 1976	13	Military photo	Recovered.
Kosmos 853	76–88A	Sept. 1, 1976	PL	A–2e	1,800?	498	243	62.8	¹ 91.7	Dec. 31, 1976	121	Communications	Probable Molniya failure.
Tyazheliy Sputnik	76–88D				5,000?	473	242	62.8	² 91.7	Dec. 9, 1976	99	Launched Kosmos 853	
Kosmos 854	76–90A	Sept. 3, 1976	PL	A–2	6,300?	337	177	81.4	¹ 89.3	Sept. 16, 1976	13	Military photo	Recovered.
Raduga 2	76–92A	Sept. 11, 1976	TT	D–1e	2,500?	35,900	35,900	0.3	¹ 1,440			Communication	Statsionar 1 position.
Tyazheliy Sputnik	76–92C				18,000?	196	189	51.5	² 88.3	Sept. 12, 1976	1	Launched Raduga	
Soyuz 22	76–93A	Sept. 15, 1976	TT	A–2	6,570?	296 280	185 250	64.8 65	² 89.3 ¹ 89.6	Sept. 23, 1976	8	Manned	Bykovskiy Aksenov used ASTP backup to fly MKF–6 camera, recovered.
Kosmos 855	76–95A	Sept. 21, 1976	PL	A–2	5,900?	366	212	72.9	¹ 89.9	Oct. 3, 1976	12	Military photo	Recovered. Mapping, geodesy, resources.
Pickaback	76–95D				200?	330	199	72.9	² 89.8	Oct. 6, 1976	17		
Kosmos 856	76–96A	Sept. 22, 1976	TT	A–2	5,900?	322	210	65	¹ 89.5	Oct. 5, 1976	13	Military photo	Recovered.
Pickaback	76–96E				200?	291	201	65.0	² 89.4	Oct. 16, 1976	24		
Kosmos 857	76–97A	Sept. 24, 1976	PL	A–2	6,300?	346	185	62.8	¹ 89.5	Oct. 7, 1976	13	Military photo	Recovered.
Kosmos 858	76–98A	Sept. 25, 1976	PL	C–1	750?	833	792	74	¹ 101			Store-dump communications	
Kosmos 859	76–99A	Oct. 10, 1976	TT	A–2	6,300?	360	180	65	¹ 89.6	Oct. 21, 1976	11	Military photo	Recovered.
Soyuz 23	76–100A	Oct. 14, 1976	TT	A–2	6,570	224 275	188 243	51.6 51.6	² 88.6 ¹ 89.6	Oct. 16, 1976	2	Manned	Zudov, Rozhdestvenskiy recovered, failed to dock with Salyut 5.

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Vertikal 4		Oct. 14, 1976	KY	C	1,300?	1,512up				Oct. 14, 1976	0	Geophysical probe	Interkosmos.
Meteor 1-26	76-102A	Oct. 15, 1976	PL	A-1	3,300?	904	871	81.3	[1] 102.5			Meteorology	
Kosmos 860	76-103A	Oct. 17, 1976	TT	F-1m	4,540?	278	260	65	[1] 89.6			Radar ocean surveillance	Moved up to higher orbit Nov. 23, 1976.
						1,008	919	64.7	[2] 104.3				
Kosmos 861	76-104A	Oct. 21, 1976	TT	F-1m	4,540?	280	256	65	[1] 89.6			Radar ocean surveillance	Moved up to higher orbit Dec. 20, 1976.
						1,005	919	64.8	[2] 104.3				
Kosmos 862	76-105A	Oct. 22, 1976	PL	A-2e	1,800?	39,300	610	62.8	[1] 709			Early warning	
Tyazheliy Sputnik	76-105C				6,000?	596	198	62.8	[2] 92.5	Dec. 10, 1976	49	Launched Kosmos 862	
Kosmos 863	76-106A	Oct. 25, 1976	PL	A-2	6,300?	370	187	62.8	[1] 89.8	Nov. 5, 1976	11	Military photo	Recovered, also Earth resources.
Ekran 1	76-107A	Oct. 26, 1976	TT	D-1e	2,700?	35,600	35,600	0.3	[1] 1,422			Communications	Statsionar T position.
Tyazheliy Sputnik	76-107C				18,000?	183	181	51.5	[2] 88.1	Oct. 27, 1976	1	Launched Ekran	
Kosmos 864	76-108A	Oct. 29, 1976	PL	C-1	680?	1,021	980	83	[1] 104.9			Navigation	3d Gen. "B".
Kosmos 865	76-109A	Nov. 1, 1976	PL	A-2	5,900?	350	212	72.9	[1] 89.8	Nov. 13, 1976	12	Military photo	Recovered.
Pickaback	76-109G				200?	384	208	72.8	[2] 90.4	Feb. 10, 1977	101		
Kosmos 866	76-110A	Nov. 11, 1976	TT	A-2	6,300?	306	182	65	[1] 89.1	Nov. 11, 1976	12	Military photo	Recovered.
Kosmos 867	76-111A	Nov. 24, 1976	PL	A-2	6,300?	418	258	62.8	[1] 91	Dec. 6, 1976	13	Military photo	Recovered.
						401	352	62.8	[2] 92.1				
Prognoz 5	76-112A	Nov. 25, 1976	TT	A-2e	905?	199,000	510	65	[1] 5,713			Geophysics	Solar wind & magnetosphere.
Tyazheliy Sputnik	76-112C				6,000?	492	205	65.0	[2] 91.5	Jan. 5, 1977	41	Launched Prognoz	
Kosmos 868	76-113A	Nov. 26, 1976	TT	F-1m	4,150?	457	438	65	[1] 93.3	July 8, 1978	589	Elint ocean surveillance	Ion propulsion.
Kosmos 869	76-114A	Nov. 29, 1976	TT	A-2	6,800?	307	202	5.18	[1] 89.3	Dec. 17, 1976	18	Man precursor	Test of Soyuz variant.
						390	268	51.8	[2] 91.1				
						309	299	51.8	[2] 90.6				
Kosmos 870	76-115A	Dec. 2, 2976	PL	C-1	875?	560	511	74	[1] 95.3	Dec. 20, 1980	1,461	Elint ferret	
Molniya 2-16	76-116A	Dec. 2, 1976	PL	A-2e	1,800?	40,608	657	62.8	[1] 736			Communications	
Tyazheliy Sputnik	76-116B				6,000?	624	211	62.9	[2] 92.9	Mar. 4, 1977	92	Launched Molniya	
Kosmos 871-878	76-118A-H	Dec. 7, 1976	PL	C-1	50?	1,520	1,450	74	[1] 115.3			Tactical communications octuple launch.	
Kosmos 879	76-119A	Dec. 9, 1976	PL	A-2	5,700?	241	217	81.4	[1] 88.9	Dec. 22, 1976	13	Military photo	Recovered.
Kosmos 880	76-120A	Dec. 9, 1976	PL	C-1	750?	624	562	66	[1] 96.4			Target for ASAT	
Kosmos 881	76-121A	Dec. 15, 1976	TT	D-1	9,500?	248	202	51.6	[1] 88.8	Dec. 15, 1976	0	Man precursor	Obscure purpose, possibly reentry tests, first of a new series.
Kosmos 882	76-121B				9,500?	248	202	51.6	[1] 88.8	Dec. 15, 1976	0	Man precursor	
Kosmos 883	76-122A	Dec. 15, 1976	PL	C-1	680?	1,023	975	83	[1] 105			Navigation	4th Gen. "B", Civil.
Kosmos 884	76-123A	Dec. 17, 1976	TT	A-2	6,300?	346	178	65	[1] 89.6	Dec. 29, 1976	12	Military photo	Recovered.
Kosmos 885	76-124A	Dec. 17, 1976	PL	C-1	900?	513	470	66	[1] 94.4	Oct. 14, 1979	1,031	Radar calibration	Broke up in March/April 1977.
Kosmos 886	76-126A	Dec. 27, 1976	TT	F-1m	3,320?	1,265	531	65.9	[2] 103			ASAT	Made close pass on Kosmos 880, then exploded.
						2,328	581	66	[1] 115				
Molniya 3-6	76-127A	Dec. 28, 1976	PL	A-2e	1,890?	40,630	640	62.8	[1] 736			Communications	
Tyazheliy Sputnik	76-127B				6,000?	573	217	62.8	[2] 92.4	Mar. 16, 1977	78	Launched Molniya	
Kosmos 887	76-128A	Dec. 28, 1976	PL	C-1	680?	1,030	973	83	[1] 104.8			Navigation	3d Gen. "B".
Kosmos 888	77-1A	Jan. 6, 1977	TT	A-2	6,300?	346	178	65	[1] 89.5	Jan. 19, 1977	13	Military photo	Recovered.

Meteor 2-2	77-2A	Jan. 7, 1977	PL	A-1	3,300?	932	830	81.3	[1] 103			Meteorology	
Kosmos 889	77-3A	Jan. 20, 1977	TT	A-2	5,700?	353	210	71.4	[1] 89.8	Feb. 1, 1977	12	Military photo	Recovered.
Kosmos 890	77-4A	Jan. 20, 1977	PL	C-1	680?	1,032	1,000	83	[1] 105			Navigation	2d Gen. "A".
Kosmos 891	77-6A	Feb. 2, 1977	PL	C-1	900?	518	466	65.8	[1] 94.4	Feb. 4, 1981	1,463	Radar calibration	
Soyuz 24	77-8A	Feb. 7, 1977	TT	A-2	6,570?	281	218	51.6	[1] 89.2	Feb. 25, 1977	18	Manned	Gorbatko, Glazkov docked with Salyut 5, recovered.
						258	251	51.6	[2] 89.5				
Kosmos 892	77-9A	Feb. 9, 1977	PL	A-2	6,300?	454	170	72.9	[1] 90.4	Feb. 22, 1977	13	Military photo	Recovered.
Molniya 2-17	77-10A	Feb. 11, 1977	PL	A-2e	1,800?	40,757	493	62.5	[1] 73.5			Communications	
Tyazheliy Sputnik	77-10B				6,000?	445	206	62.8	[2] 91.0	Mar. 13, 1977	30	Launched Molniya	
Kosmos 893	77-11A	Feb. 15, 1977	PL	C-1	710?	1,703	341	74	[1] 105.3			Geophysics	Could be a failed interkosmos.
Kosmos 894	77-13A	Feb. 21, 1977	PL	C-1	680?	1,026	988	83	[1] 105.1			Navigation	3d Gen. "B".
Kosmos 895	77-15A	Feb. 27, 1977	PL	A-1	3,800?	648	613	81.2	[1] 97.2			Elint Ferret	
Kosmos 896	77-16A	Mar. 3, 1977	PL	A-2	6,300?	216	194	72.9	[1] 88.5	Mar. 16, 1977	13	Military photo	Recovered.
						343	197	72.9	[2] 89.7				
Kosmos 897	77-17A	Mar. 10, 1977	PL	A-2	6,300?	371	182	72.9	[1] 89.7	Mar. 23, 1977	13	Military photo	Recovered.
Kosmos 898	77-20A	Mar. 17, 1977	PL	A-2	5,900?	258	222	81.4	[1] 89.0	Mar. 30, 1977	13	Military photo	Recovered.
Pickaback	77-20D				200?	217	210	81.3	[2] 88.8	Apr. 3, 1977	17		
Molniya 1-36	77-21A	Mar. 24, 1977	PL	A-2e	1,750?	40,816	484	62.8	[1] 736			Communications	
Tyazheliy Sputnik	77-21B				6,000?	439	211	62.8	[2] 91.0	Apr. 19, 1977	26	Launched Molniya	
Kosmos 899	77-22A	Mar. 24, 1977	PL	C-1	875?	552	505	74.1	[1] 95.2	Oct. 19, 1980	1,305	Elint Ferret	
Kosmos 900	77-23A	Mar. 29, 1977	PL	C-1	860?	523	460	83	[1] 94			Geophysics	
Meteor 1-27	77-24A	Apr. 5, 1977	PL	A-1	3,300?	909	869	81.2	[1] 102.5			Meteorology	
Kosmos 901	77-25A	Apr. 5, 1977	PL	B-1	300?	845	279	71	[1] 95.5	June 28, 1978	449	Radar Calibration	
Kosmos 902	77-26A	Apr. 7, 1977	PL	A-2	6,300?	307	179	81.4	[1] 89	Apr. 20, 1977	13	Military photo	Recovered.
Kosmos 903	77-27A	Apr. 11, 1977	PL	A-2e	1,800?	40,170	630	62.8	[1] 726			Early warning	
Tyazheliy Sputnik	77-27B				6,000?	573	213	62.8	[2] 92.4	June 6, 1977	56	Launched Kosmos 903	
Kosmos 904	77-28A	Apr. 20, 1977	TT	A-2	5,700?	350	210	71.4	[1] 89.8	May 4, 1977	14	Military photo	Recovered.
Kosmos 905	77-30A	Apr. 26, 1977	PL	A-2	6,700?	366	179	67.1	[1] 89.7	May 26, 1977	30	Military photo	Recovered, Solar panels.
						413	170	67.1	[2] 90.3				
Kosmos 906	77-31A	Apr. 27, 1977	KY	C-1	980?	523	466	50.7	[1] 94.3	Mar. 23, 1980	1,061	Geophysics	Possible interkosmos failure.
Molniya 3-7	77-32A	Apr. 28, 1977	PL	A-2e	1,890?	40,817	467	62.8	[1] 736			Communications	
Tyazheliy Sputnik	77-32B				6,000?	384	210	62.8	[2] 90.5	May 15, 1977	17	Launched Molniya	
Kosmos 907	77-33A	May 5, 1977	PL	A-2	6,300?	388	187	62.8	[1] 89.9	May 16, 1977	11	Military photo	Recovered.
Kosmos 908	77-35A	May 17, 1977	TT	A-2	6,300?	307	180	51.8	[1] 89.1	May 31, 1977	14	Military photo	Recovered.
Kosmos 909	77-36A	May 19, 1977	PL	C-1	630?	2,112	991	65.9	[1] 117			Target for ASAT	
Kosmos 910	77-37A	May 23, 1977	TT	F-1m	3,320?	560	149	65.1	[1] 91	May 23, 1977	0	ASAT	Intended to attack Kosmos 909, results unclear, plunged into Pacific.
						1,774	300	65.9	[2] 91.6				
Kosmos 911	77-39A	May 25, 1977	PL	C-1	600?	1,018	984	82.9	[1] 104.9			Geodetic	
Kosmos 912	77-40A	May 26, 1977	PL	A-2	5,900?	257	219	81.4	[1] 89	June 8, 1977	13	Military photo	Recovered, also Earth resources.
Pickaback	77-40E				200?	227	210	81.4	88.9	June 18, 1977	23		
Kosmos 913	77-42A	May 30, 1977	PL	C-1	900?	523	475	74	[1] 94.5	Dec. 29, 1979	943	Radar calibration	Exploded September 1977.
Kosmos 914	77-43A	May 31, 1977	TT	A-2	5,900?	327	210	65	[1] 89.6	June 13, 1977	13	Military photo	Recovered.
Pickaback	77-43E				200?	306	203	65.0	[2] 89.6	July 2, 1977	32		
Kosmos 915	77-45A	June 8, 1977	PL	A-2	6,300?	306	182	62.8	[1] 89.1	June 21, 1977	13	Military photo	Recovered.
Kosmos 916	77-46A	June 10, 1977	PL	A-2	5,900?	307	250	62.8	[1] 89.9	June 21, 1977	12	Military photo	Recovered. Mapping, geodesy, resources.
Pickaback	77-46G				200?	286	247	62.8	[2] 89.8	July 1, 1977	21		
Kosmos 917	77-47A	June 16, 1977	PL	A-2e	1,800?	40,150	625	62.9	[1] 725			Early warning	
Tyazheliy Sputnik	77-47B				6,000?	569	216	62.8	[2] 92.4	Aug. 17, 1977	62	Launched Kosmos 917	
Sneg 3	77-49A	June 17, 1977	KY	C-1	102	519	459	50.7	[1] 94.3	June 20, 1979	733	Geophysics	French Signe gamma-ray studies.
Kosmos 918	77-50A	June 17, 1977	TT	F-1m	3,320?	265	131	65.1	[1] 88.4	June 18, 1977	1	ASAT	Made close approach to Kosmos 909, plunged into Pacific.
Kosmos 919	77-51A	June 18, 1977	PL	B-1	300?	847	278	71	[1] 95.6	Aug. 28, 1978	436	Radar calibration	

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 920	77–52A	June 22, 1977	TT	A–2	6,300?	364	180	65	[1] 89.7	July 5, 1977	13	Military photo	Recovered.
Molniya 1–37	77–54A	June 24, 1977	TT	A–2m	1,750?	39,016	480	62.9	[1] 700			Communications	
Tyazheliy Sputnik	77–54B				6,000?	472	235	62.9	[2] 91.6	Aug. 24, 1977	61	Launched Molniya	
Kosmos 921	77–55A	June 24, 1977	PL	F–2	6,500?	711	644	76	[1] 98			Vehicle test	First of a new series.
Meteor 1–28	77–57A	June 29, 1977	TT	A–1	3,475?	685	602	98	[1] 97.5			Meterology	First retrograde—Sunsynchronous orbit.
Kosmos 922	77–58A	June 30, 1977	PL	A–2	5,700?	323	212	62.8	[1] 89.5	July 13, 1977	13	Military photo	Recovered.
Kosmos 923	77–59A	July 1, 1977	PL	C–1	750?	842	804	74	[1] 101.4			Store-dump communications	
Kosmos 924	77–60A	July 4, 1977	PL	C–1	875?	560	514	74	[1] 95.3	Feb. 10, 1981	1,317	Elint ferret	
Kosmos 925	77–61A	July 7, 1977	PL	A–1	3,800?	645	622	81.2	[1] 97.2			Elint ferret	
Kosmos 926	77–62A	July 8, 1977	PL	C–1	680?	1,025	997	82.9	[1] 105.1			Navigation	4th Gen. "B", Civil.
Kosmos 927	77–63A	July 12, 1977	PL	A–2	6,300?	403	178	72.9	[1] 90	July 25, 1977	13	Military photo	Recovered.
Kosmos 928	77–64A	July 13, 1977	PL	C–1	680?	1,022	977	83	[1] 104.8			Navigation	3d Gen. "B".
Kosmos 929	77–66A	July 17, 1977	TT	D–1	20,000?	298	221	51.6	[1] 89.4	Feb. 2, 1978	200	Man precursor	Obscure mission, returned portion Aug. 16, 1977, extensive maneuvers.
						318	312	51.6	[2] 90.8				
						447	438	51.6	[2] 93.4				
Kosmos 930	77–67A	July 19, 1977	PL	C–1	900?	528	482	74	[1] 94.6	May 12, 1980	1,028	Radar calibration	
Kosmos 931	77–68A	July 20, 1977	PL	A–2e	1,800?	40,180	600	62.8	[1] 726			Early warning	
Tyazheliy Sputnik	77–68B				6,000?	591	212	62.8	[2] 92.6	Sept. 22, 1977	64	Launched Kosmos 931	
Kosmos 932	77–69A	July 20, 1977	TT	a–2	6,300?	342	180	65	[1] 89.5	Aug. 2, 1977	13	Military photo	Recovered.
Kosmos 933	77–70A	July 22, 1977	PL	C–1	900?	418	385	65.8	[1] 92.5	Nov. 1, 1978	467	Radar calibration	
Raduga 3	77–71A	July 23, 1977	TT	D–1e	2,500?	36,600	36,600	0.4	[1] 1474			Communications	Statsionar 2.
Tyazheliy Sputnik	77–71C				18,000?	195	191	51.5	[2] 88.3	July 26, 1977	3	Launched Raduga	
Kosmos 934	77–72A	July 27, 1977	PL	A–2	6,300?	264	238	62.8	[1] 89.4	Aug. 9, 1977	13	Military photo	Recovered.
Kosmos 935	77–73A	July 29, 1977	PL	A–2	5,700?	276	225	81.3	[1] 89.2	Aug. 11, 1977	13	Military photo	Recovered.
Kosmos 936	77–74A	Aug. 3, 1977	PL	A–2	5,500?	419	224	62.8	[1] 90.7	Aug. 22, 1977	19	Biology	Recovered.
Pickaback	77–74D				200?	375	215	62.8	[2] 90.4	Oct. 8, 1977	66		
Kosmos 937	77–77A	Aug. 24, 1977	TT	F–1m	4,150?	597	149	65.1	[2] 92.1	Oct. 19, 1978	421	Elint ocean surveillance	Ion propulsion.
						457	438	65	[1] 93.3				
Kosmos 938	77–78A	Aug. 24, 1977	PL	A–2	6,300?	365	189	62.8	[1] 89.7	Sept. 6, 1977	13	Military photo	Recovered.
Kosmos 939–946	77–79A–H	Aug. 24, 1977	PL	C–1	50?	1,518	1,448	74	[1] 115.2			Tactical communications octuple launch.	
Kosmos 947	77–81A	Aug. 27, 1977	PL	A–2	5,700?	346	211	72.8	[1] 89.7	Sept. 9, 1977	13	Military photo	Recovered.
Vertikal 5		Aug. 30, 1977	KY	C	3,000?	500 up				Aug. 30, 1977	0	Geophysical probe	Interkosmos.
Molniya 1–38	77–82A	Aug. 30, 1977	PL	A–2e	1,750?	40,000	480	62.8	[1] 73.6			Communications	
Tyazheliy Sputnik	77–82C				6,000?	464	198	62.8	[2] 91.1	Sept. 23, 1977	24	Launched Molniya	
Kosmos 948	77–83A	Sept. 2, 1977	PL	A–2	5,900?	265	217	81.4	[1] 89	Sept. 15, 1977	13	Military photo	Recovered, also Earth resources.
Pickaback	77–83C				200?	214	204	81.3	[2] 88.7	Sept 20, 1977	18		
Kosmos 949	77–85A	Sept. 6, 1977	PL	A–2	6,700?	348	184	62.8	[1] 89.5	Oct. 6, 1977	30	Military photo	Recovered. Solar panels.
						364	177	62.8	[2] 89.9				
Kosmos 950	77–86A	Sept. 13, 1977	PL	A–2	5,700?	305	213	62.8	[1] 89.4	Sept 27, 1977	14	Military photo	Recovered.
Kosmos 951	77–87A	Sept. 13, 1977	PL	C–1	680?	1,029	989	83	[1] 105			Navigation	3d Gen. "B".

Kosmos 952	77-88A	Sept 16, 1977	TT	F-1m	4,540?	278	258	65	[1]89.7			Radar ocean surveillance	Moved up to higher orbit Oct. 8, 1977.
						998	910	65.0	[2]104.1				
Kosmos 953	77-89A	Sept. 16, 1979	PL	A-2	6,300?	354	188	62.8	[1]89.6	Sept. 29, 1977	13	Military photo	Recovered.
Kosmos 954	77-90A	Sept. 18, 1977	TT	F-1m	4,540?	277	259	65	[1]89.6	Jan 24, 1978	128	Radar ocean surveillance	Difficulties in control after Nov. 1, 1977, ultimately fell in NWT, Canada with nuclear reactor.
Kosmos 955	77-91A	Sept. 20, 1977	PL	A-1	3,800?	664	631	81.2	[1]97.5			Elint ferret	
Ekran 2	77-92A	Sept. 20, 1977	TT	D-le	2,700?	35,560	35,560	0.4	[1]1,425			Communications	Statsionar T.
Tyazheliy Sputnik	77-92C				18,000?	192	186	51.4	[2]88.2	Sept. 21, 1977	1	Launched Ekran	
Prognoz 6	77-93A	Sept. 22, 1977	TT	A-2e	910	197,900	498	65	[1]5,688			Geophysics	Solar wind, magnetosphere.
Tyazheliy Sputnik	77-93C				6,000?	471	207	65.1	[2]91.3	Oct. 23, 1977	31	Launched Prognoz	
Kosmos 956	77-95A	Sept. 24, 1977	PL	F-2	6,660?	865	358	75.8	[1]96.9			Vehicle test	
Interkosmos 17	77-96A	Sept. 24, 1977	PL	C-1	550?	519	468	83	[1]94.4	Nov. 8, 1979	775	Geophysics	Upper atmosphere and magnetosphere, lasertelescope for geodetics.
Salyut 6	77-97A	Sept. 29, 1977	TT	D-1	18,900?	275	219	51.6	[1]89.1			Manned station	Civilian version, long duration through resupply.
						360	345	51.6	[2]91.3				
Kosmos 957	77-98A	Sept. 30, 1977	TT	A-2	6,300?	381	181	65	[1]89.8	Oct. 13, 1977	13	Military photo	Recovered.
Soyuz 25	77-99A	Oct. 9, 1977	TT	A-2	6,570?	240	194	51.6	[2]88.8	Oct. 11, 1977	2	Manned	Kovalenok, Ryumin failed to dock with Salyut 6, recovered.
						318	280	51.6	[1]90.2				
						353	329	51.6	[2]91.3				
Kosmos 958	77-100A	Oct. 11, 1977	PL	A-2	6,300?	369	265	62.8	[1]90.5	Oct. 24, 1977	13	Military photo	Recovered.
						420	323	62	[2]92.0				
Kosmos 959	77-101A	Oct. 21, 1977	PL	C-1	750?	891	153	66	[1]94.8	Nov. 30, 1977	40	Target for ASAT	
Kosmos 960	77-103A	Oct. 25, 1977	PL	C-1	875?	549	505	74	[1]95.1	Oct. 22, 1980	1,093	Elint ferret	
Vertikal 6		Oct. 25, 1977	KY	C	1,300?	1,500up				Oct. 25, 1977	0	Geophysical probe	Interkosmos.
Kosmos 961	77-104A	Oct. 26, 1977	TT	F-1m	3,320?	302	125	66	[1]101.8	Oct. 26, 1977	0	ASAT	Approached Kosmos 959, plunged into Pacific.
						1,421	269	66.4					
Molniya 3-8	77-105A	Oct. 28, 1977	PL	A-2e	1,890?	40,764	478	62.8	[1]735			Communications	
Tyazheliy Sputnik	77-105C				6,000?	454	208	62.8	[2]91.1	Nov. 26, 1977	29	Launched Molniya	
Kosmos 962	77-107A	Oct. 28, 1977	PL	C-1	680?	1,022	983	83	[1]104.9			Navigation	2d Gen., "A".
Kosmos 963	77-109A	Nov. 24, 1977	PL	C-1	600?	1,220	1,190	82.9	[1]109.3			Geodetic	
Kosmos 964	77-110A	Dec. 4, 1977	PL	A-2	6,300?	391	180	72.9	[1]89.9	Dec. 17, 1977	13	Military photo	Recovered.
Kosmos 965	77-111A	Dec. 8, 1977	PL	C-1	900?	520	469	74	[1]94.4	Dec. 16, 1979	738	Radar calibration	Broke up or exploded.
Soyuz 26	77-113A	Dec. 10, 1977	TT	A-2	6,570?	235	195	51.6	[2]88.7	Jan. 16, 1978	37	Manned	Romanenko, Grechko docked with Salyut 6, returned with Dzhanibekov, Makarov.
						354	337	51.6	[1]91.4				
Kosmos 966	77-115A	Dec. 12, 1977	TT	A-2	5,900?	316	210	65	[1]89.5	Dec. 24, 1977	12	Military photo	Recovered.
Pickaback	77-115D				200?	268	196	65.0	[2]89.1	Jan. 7, 1978	26		
Kosmos 967	77-116A	Dec. 13, 1977	PL	C-1	750?	1,013	973	66	[1]105			Target for ASAT	
Meteor 2-3	77-117A	Dec. 14, 1977	PL	A-1	3,300?	906	872	81.2	[1]102.5			Meteorology	
Kosmos 968	77-119A	Dec. 16, 1977	PL	C-1	750?	822	783	74	[1]101			Store-dump communications	
Kosmos 969	77-120A	Dec. 20, 1977	PL	A-2	6,300?	340	188	62.8	[1]89.5	Jan. 3, 1978	14	Military photo	Recovered.
Kosmos 970	77-121A	Dec. 21, 1977	TT	F-1m	3,320?	1,160	954	65.8	[1]106			ASAT	Close pass on Kosmos 967, then exploded.
Kosmos 971	77-122A	Dec. 23, 1977	PL	C-1	680?	1,021	993	83	[1]105			Navigation	3d Gen. "B".
Kosmos 972	77-123A	Dec. 27, 1977	PL	F-2	5,600?	1,189	722	75.8	[1]104			Vehicle test	
Kosmos 973	77-124A	Dec. 27, 1977	TT	A-2	5,900?	348	210	71.4	[1]89.8	Jan. 9, 1978	13	Military photo	Recovered.
Pickaback	77-124D				200?	312	199	71.4	[2]89.6	Jan. 25, 1978	29		
Kosmos 974	78-1A	Jan. 6, 1978	PL	A-2	6,300?	356	188	62.8	[1]89.6	Jan. 19, 1978	13	Military photo	Recovered.
Soyuz 27	78-3A	Jan. 10, 1978	TT	A-2	6,570?	237	190	51.7	[2]88.7	Mar. 16, 1978	65	Manned	Dzhanibekov, Makarov docked with Solyut 6, recovered with Romanenko, Grechko.
						350	330	51.6	[1]91.3				

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 975	78–4A	Jan. 10, 1978	PL	A–1	3,800?	680	637	81.2	[1]97.6			Elint ferret	
Kosmos 976-983	78–5A-H	Jan. 10, 1978	PL	C–1	50?	1,520	1,452	74	[1] 115.3			Tactical communications octuple launch.	
Kosmos 984	78–6A	Jan. 13, 1978	PL	A–2	5,700?	313	215	62.8	[1] 89.5	Jan. 26,, 1978	9	Military photo	Recovered.
Kosmos 985	78–7A	Jan. 17, 1978	PL	C–1	680?	1,032	960	83	[1] 105			Navigation	3d Gen. "B".
Progress 1	78–8A	Jan. 20, 1978	TT	A–2	7,020	262	194	51.6	[1] 88.8	Feb. 8, 1978	19	Man logistics	Docked with Satyul 6, burned up over Pacific.
						346	329	51.6	[2] 91.3				
Molniya 3–9	78–9A	Jan. 24, 1978	PL	A–2e	1,890?	40,631	661	62.8	[1] 736			Communications	
Tyazheliy Sputnik	78–9C				6,000?	643	219	62.8	[2] 932	Mar. 3, 1978	38	Launched Molniya	
Kosmos 986	78–10A	Jan. 24, 1978	TT	A–2	6,300?	341	179	65	[1] 89.4	Feb. 7,, 1978	14	Military photo	Recovered.
Kosmos 987	78–13A	Jan. 31, 1978	TT	A–2	6,300?	359	183	62.8	[1] 89.6	Feb. 14, 1978	14	Military photo	Recovered.
Kosmos 988	78–15A	Feb. 8, 1978	PL	A–2	5,900?	363	210	72.8	[1] 89.9	Feb. 20, 1978	12	Military photo	Recovered, mapping, geodesy, resources.
Pickaback	78–15F				200?	335	201	72.8	[2] 89.9	Mar. 11, 1978	31		
Kosmos 989	78–17A	Feb. 14, 1978	TT	A–2	6,300?	354	178	65	[1] 89.5	Feb. 28, 1978	14	Military photo	Recovered.
Kosmos 990	78–19A	Feb. 17, 1978	PL	C–1	750?	824	783	74	[1] 101			Store-dump communications	
Kosmos 991	78–22A	Feb. 28, 1978	PL	C–1	680?	1,022	972	83	[1] 104.8			Navigation	3d Gen. "B".
Soyuz 28	78–23A	Mar. 2, 1978	TT	A–2	6,570?	246	192	51.6	[2] 88.8	Mar. 10, 1978	8	Manned	Gubarev, Remek docked with Salyut 6, recovered.
						353	334	51.6	[1] 91.4				
Molniya 1–39	78–24A	Mar. 2, 1978	PL	A–2e	1,750?	40,733	632	62.8	[1] 738			Communications	
Tyazheliy Sputnik	78–24B				6,000?	605	210	62.8	[2] 92.7	Apr. 10, 1978	39	Launched Molniya	
Kosmos 992	78–25A	Mar. 4, 1978	TT	A–2	5,700?	346	210	71.4	[1] 89.8	Mar. 17, 1978	13	Military photo	Recovered.
Kosmos 993	78–27A	Mar. 10, 1978	PL	A–2	6,300?	368	182	72.9	[1] 89.7	Mar. 23, 1978	13	Military photo	Recovered.
Kosmos 994	78–28A	Mar. 15, 1978	PL	C–1	680?	1,023	996	82,9	[1] 105			Navigation	2d Gen. "A".
Kosmos 995	78–30A	Mar. 17, 1978	PL	A–2	5,700?	262	221	81.4	[1] 89.1	Mar. 30, 1978	13	Military photo	Recovered.
Kosmos 996	78–31A	Mar. 28, 1978	PL	C–1	680?	1,020	970	82.9	[1] 104.8			Navigation	3d Gen. "B".
Kosmos 997	78–32A	Mar. 30, 1978	TT	D–1	9,500?	230	200	51.6	[1] 88.7	Mar. 30, 1978	0	Man precursor	Obscure purpose, possible reentry tests.
Kosmos 998	78–32B				9,500?	230	200	51.6	[1] 88.7	Mar. 30, 1978	0	Man precursor	
Kosmos 999	78–33A	Mar. 30, 1978	TT	A–2	6,300?	376	180	71.4	[1] 89.9	Apr. 12, 1978	13	Military photo	Recovered.
Kosmos 1000	78–34A	Mar. 31, 1978	PL	C–1	680?	1,024	978	83	[1] 104.9			Navigation	4th Gen. "B", Civil. First announcement of this mission.
Kosmos 1001	78–36A	Apr. 4, 1978	TT	A–2	7,000?	249	205	51.6	[1] 88.7	Apr. 15, 1978	11	Man precursor	Soyuz variant (Soyuz T).
						315	308	51.6	[2] 90.7				
Kosmos 1002	78–37A	Apr. 6, 1978	TT	A–2	500?	305	209	65	[1] 89.4	Apr. 19, 1978	13	Military photo	Recovered.
Kosmos 1003	78–40A	Apr. 20, 1978	PL	A–2	6,300?	349	185	62.8	[1]89.6	May 4, 1978	14	Military photo	Recovered.
Kosmos 1004	78–43A	May 5, 1978	PL	A–2	5,900?	311	213	62.8	[1]89.4	May 18, 1978	13	Military photo	Recovered.
Pickaback	78–43G				200?	431	204	62.8	[2]90.9	June 6, 1978	42		
Kosmos 1005	78–45A	May 12 1978	PL	A–1	3,800?	672	626	81.2	[1]97.6			Elint ferret	
Kosmos 1006	78–46A	May 12, 1978	PL	C–1	900?	417	383	65.8	[1]92.5	Mar. 14, 1979	306	Radar calibration	
Kosmos 1007	78–48A	May 16, 1978	PL	A–2	6,300?	384	180	72.9	[1]89.8	May 29, 1978	13	Military photo	Recovered, also Earth resources.
Kosmos 1008	78–49A	May 17, 1978	PL	C–1	975?	551	501	74	[1]95.1	Jan. 8, 1981	967	Elint ferret	

Kosmos 1009	78-50A	May 19, 1978	TT	F-1m	3,320?	1,378	971	66	[1]109	May 19, 1978	0	ASAT	Made approach to Kosmos 967, plunged into Pacific.
Kosmos 1010	78-52A	May 23, 1978	PL	A-2	6,300?	257	218	81.4	[1]89	June 5, 1978	13	Military photo	Recovered.
Kosmos 1011	78-53A	May 23, 1978	PL	C-1	680?	1,026	978	82.9	[1]104.9			Navigation	3d Gen. "B".
Kosmos 1012	78-54A	May 25, 1978	PL	A-2	5,700?	280	214	62.8	[1]89.2	June 7, 1978	13	Military photo	Recovered.
Molniya 1-40	78-55A	Jun. 2, 1978	PL	A-2e	1,750?	40,837	457	62.5	[1]736			Communications	
Tyazheliy Sputnik	78-55B				6,000?	422	211	62.9	[2]90.9	June 21, 1978	19	Launched Molniya	
Kosmos 1013-1020	78-56A-H	Jun. 7, 1978	PL	C-1	50?	1,539	1,456	74	[1]115.6			Tactical communications octuple launch.	
Kosmos 1021	78-57A	June 10, 1978	TT	A-2	6,300?	336	180	65	[1]89.4	June 23, 1978	13	Military photo	Recovered.
Kosmos 1022	78-59A	June 12, 1978	PL	A-2	6,300?	374	182	72.9	[1]89.7	June 25, 1978	13	Military photo	Recovered.
Soyuz 29	78-61A	June 15, 1978	TT	A-2	6,570?	248	193	51.6	[2]88.9	Sept. 3, 1978	80	Manned	Kovalenok, Ivanchenkov docked with Salyut 6, recovered with Bykovskiy, Jahn.
						368	338	51.6	[1]91.4				
Kosmos 1023	78-63A	June 21, 1978	PL	C-1	750?	822	784	74.1	[1]100.8			Store-dump communications	
Soyuz 30	78-65A	June 27, 1978	TT	A-2	6,570?	244	194	51.6	[2]88.8	July 5, 1978	8	Manned	Klimuk, Hermaszewski docked with Salyut 6, recovered.
						360	336	51.6	[1]91.2				
Kosmos 1024	78-66A	June 28, 1978	PL	A-2e	1,800?	40,000	630	62.8	[1]726			Early warning	
Tyazheliy Sputnik	78-66C				6,000?	547	212	62.8	[2]92.1	July 12, 1978	14	Launched Kosmos 1024	
Kosmos 1025	78-67A	June 28, 1978	PL	F-2	6,320?	680	649	82.5	[1]97.8			Elint ocean surveillance	Possible development flight.
Kosmos 1026	78-69A	July 2, 1978	TT	A-2	5,700?	261	209	51.8	[1]89	July 6, 1978	4	Military photo	Recovered, mission purpose in doubt.
Progress 2	78-70A	July 7, 1978	TT	A-2	7,020	262	193	51.6	[1]88.7	Aug. 4, 1978	28	Man logistics	Docked with Salyut 6, burned over the Pacific.
						308	245	51.6	[2]90.0				
Molniya 1-41	78-72A	July 14, 1978	PL	A-2e	1,750?	40,660	650	62.8	[1]737			Communications	
Tyazheliy Sputnik	78-72C				6,000?	616	204	62.8	[2]92.7	Aug. 23, 1978	40	Launched Molniya	
Raduga 4	78-73A	July 18, 1978	TT	D-1e	2,500?	36,590	36,590	0.5	[1]147.8			Communications	Statsionar 2 position.
Tyazheliy Sputnik	78-73C				18,000?					July 19, 1978	1	Launched Raduga	
Kosmos 1027	78-74A	July 27, 1978	PL	C-1	680?	1,015	979	82.9	[1]104.8			Navigation	2d Gen. "A".
Kosmos 1028	78-76A	Aug. 5, 1978	PL	A-2	6,700?	272	182	67.1	[1]88.7	Sept. 4, 1978	30	Military photo	Recovered, Solar panels.
						337	168	67.1	[2]89.5				
Progress 3	78-77A	Aug. 7, 1978	TT	A-2	7,020	249	195	51.6	[1]88.7	Aug. 23, 1978	16	Man logistics	Docked with Salyut 6, burned over the Pacific.
						359	343	51.6	[2]91.4				
Molniya 1-42	78-80A	Aug. 22, 1978	PL	A-2e	1,750?	40,788	480	62.8	[1]736			Communications	
Tyazheliy Sputnik	78-80C				6,000?	439	211	62.8	[2]91.0	Sept. 6, 1978	15	Launched Molniya	
Soyuz 31	78-81A	Aug. 26, 1978	TT	A-2	6,570?	243	193	51.6	[2]88.8	Nov. 2, 1978	68	Manned	Bykovskiy, Jahn docked with Salyut 6, recovered with Kovalenok, Ivanchenkov.
						354	334	51.6	[1]91.4				
Kosmos 1029	78-82A	Aug. 29, 1978	PL	A-2	6,300?	353	186	62.8	[1]89.6	Sept. 8, 1978	10	Military photo	Recovered.
Kosmos 1030	78-83A	Sept. 6, 1978	PL	A-Ze	1,800?	40,100	650	62.8	[1]725.6			Early warning	
Tyazheliy Sputnik	78-83C				6,000?	622	173	62.9	[2]92.5	Sept. 21, 1978	15	Launched Kosmos 1030	
Venera 11	78-84A	Sept. 9, 1978	TT	D-1e	4,940?	1.11au	.70au	2.3	[2,5]316			Venus	Passed Venus at 35,000 km Dec. 25, 1978, served as relay station.
Tyazheliy Sputnik	78-84C				18,000?	205	170	51.6	[2]88.2	Sept. 10, 1978	1	Launched Venera 11	
Lander	78-84E				1,560?					Dec. 25, 1978	107		Soft-landed on Venus.
Kosmos 1031	78-85A	Sept. 12, 1978	PL	A-2	6,300?	351	191	62.8	[1]89.6	Sept. 22, 1978	13	Military photo	Recovered.

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Venera 12	78–86A	Sept. 14, 1978	TT	D–1e	4,940?	1.11au	.70au	2.3	[2,5] 316			Venus	Passed Venus at 35,000 km Dec. 21, 1978, served as relay station.
Tyazheliy Sputnik	78–86B				18,000?	207	164	51.5	[2] 88.2	Sept. 15, 1978	1	Launched Venera 12	
Lander	78–86E				1,560?					Dec. 21, 1978	98		Soft-landed on Venus.
Kosmos 1032	78–88A	Sept. 19, 1978	PL	A–2	5,900?	249	218	81.4	[1] 88.9	Oct. 2, 1978	13	Military photo	Recovered.
Pickaback	78–88D				200?	186	171	81.3	[3] 88.0	Oct. 3, 1978	14		
Kosmos 1033	78–89A	Oct. 3, 1978	PL	A–2	5,900?	268	223	81.4	[1] 89.1	Oct. 16, 1978	13	Military photo	Recovered, also Earth resources.
Pickaback	78–89C				200?	202	189	81.4	[2] 88.4	Oct. 17, 1978	14		
Progress 4	78–90A	Oct. 3, 1978	TT	A–2	7,020	266	191	51.7	[1] 88.8	Oct. 26, 1978	23	Man logistics	Docked with Salyut 6, burned up over Pacific.
						362	359	51.6	[2] 91.7				
Kosmos 1034–1041	78–91A–H	Oct. 4, 1978	PL	C–1	50?	1,536	1,458	74	[1] 115.8			Tactical communications octuple launch.	
Kosmos 1042	78–92A	Oct. 6, 1978	PL	A–2	6,300?	326	187	62.8	[1] 89,3	Oct. 19, 1978	13	Military photo	Recovered.
Kosmos 1043	78–94A	Oct. 10, 1978	PL	A–1	3,800?	650	625	81.1	[1] 97.3			Elint ferret	
Molniya 3–10	78–95A	Oct. 13, 1978	PL	A–2e	1,890?	40,825	467	62.8	[1] 736			Communications	
Tyazheliy Sputnik	78–95C				6,000?	422	175	62.8	[2] 90.5	Oct. 20, 1978	7	Launched Molniya	
Kosmos 1044	78–97A	Oct. 17, 1978	PL	A–2	5,700?	315	211	62.8	[1] 89.5	Oct. 30, 1978	13	Military photo	Recovered.
Interkosmos 18	78–99A	Oct 24, 1978	PL	C–1	550?	786	407	83	[1] 96.4			Geophysics	Magnetosphere and ionosphere studies.
Magion	78–99C				15	762	404	83.0	[2] 96.3			Geophysics	Czech subsatellite for magnetic and ionospheric studies.
Kosmos 1045	78–100C	Oct. 26, 1978	PL	F–2	3,400?	1,724	1,688	82.6	[1] 120.4			Ocean elint	Obscure mission.
Radio 1	78–100A				40	1,724	1,688	82.6	[1] 120.4			Communications	Amateur radio.
Radio 2	78–100B				40	1,724	1,688	82.6	[1] 120.4			Communications	Amateur radio.
Prognoz 7	78–101A	Oct. 30, 1978	TT	A–2E	910?	202,965	483	65	[1] 5,888	Sept. 22, 1980	693	Geophysics	Solar wind, magnetosphere.
Tyazheliy Sputnik	78–101C				6,000?	429	233	65.0	[2] 91.1	Nov. 25, 1978	26	Launched Prognoz	
Kosmos 1046	78–102A	Nov. 1, 1978	PL	A–2	5,900?	353	212	72.9	[1] 89.9	Nov. 13, 1978	12	Military photo	Recovered. Mapping, geodesy, resources.
Pickaback	78–102D				200?	324	202	72.9	[2] 89.8	Nov. 15, 1978	14		
Vertikal 7		Nov. 3, 1978	KY	C	1,300?	1,500up				Nov. 3, 1978	0	Geophysical probe	Interkosmos.
Kosmos 1047	78–104A	Nov. 15, 1978	PL	A–2	6,300?	378	182	72.9	[1] 89.8	Nov. 28, 1978	13	Military photo	Recovered.
Kosmos 1048	78–105A	Nov. 16, 1978	PL	C–1	750?	824	788	74	[1] 101			Store-dump communications	
Kosmos 1049	78–107A	Nov. 21, 1978	PL	A–2	6,300?	375	183	72.9	[1] 89.7	Dec. 4, 1978	13	Military photo	Recovered.
Kosmos 1050	78–108A	Nov. 28, 1978	PL	A–2	6,300?	298	258	62.8	[1] 89.8	Dec. 12, 1978	14	Military photo	Recovered.
Kosmos 1051–1058	78–109A–H	Dec. 5, 1978	PL	C–1	50?	1,530	1,451	74	[1] 115.5			Tactical communications octuple launch.	

Kosmos 1059	78–110A	Dec. 7, 1978	PL	A–2	6,300?	360	188	62.8	[1] 89.7	Dec. 20, 1978	13	Military photo	Recovered.
Kosmos 1060	78–111A	Dec. 8, 1978	TT	A–2	5,700?	311	209	65	[1] 89.5	Dec. 21, 1978	13	Military photo	Recovered.
Kosmos 1061	78–114A	Dec. 14, 1978	PL	A–2	5,900?	333	211	62.8	[1] 89.6	Dec. 27, 1978	13	Military photo	Recovered.
Pickaback	78–114C				200?	310	203	62.8	[2] 89.6	Jan. 9, 1979	21		
Kosmos 1062	78–115A	Dec. 15, 1978	PL	C–1	875?	548	508	74	[1] 95.1			Elint ferret	
Kosmos 1063	78–117A	Dec. 19, 1978	PL	A–1	3,800?	661	632	81.2	[1] 97.5			Elint ferret	
Gorizont 1	78–118A	Dec. 19, 1978	TT	D–1e	2,880?	48,365	22,581	11.3	[1] 1,420			Communications	Apparently failed to reach planned orbit.
Tyazheliy Sputnik	78–118D				18,000?	~190	~174	51.6	[2] 88.1	Dec. 21, 1978	2	Launched Gorizont	
Kosmos 1064	78–119A	Dec. 20, 1978	PL	C–1	680?	991	435	83	[1] 98.7			Navigation	3d Gen. "B", wrong orbit.
Kosmos 1065	78–120A	Dec. 22, 1978	KY	C–1	900?	556	346	50.7	[1] 93.7	Aug. 1, 1979	222	Radar calibration	
Kosmos 1066	78–121A	Dec. 23, 1978	PL	A–1	3,300?	908	848	81.2	[1] 102.2			Meterorology	Possible Meteor 2 failure.
Kosmos 1067	78–122A	Dec. 26, 1978	PL	C–1	600?	1,226	1,184	83	[1] 109.2			Geodetics	
Kosmos 1068	78–123A	Dec. 26, 1978	PL	A–2	6,300?	401	187	62.8	[1] 90.2	Jan. 8, 1979	13	Military photo	Recovered.
Kosmos 1069	78–124A	Dec. 28, 1978	PL	A–2	5,900?	290	244	62.8	[1] 89.8	Jan. 10, 1979	13	Military photo	Recovered. Mapping, geodesy, resources.
Pickaback	78–124F				200?	285	241	62.8	[2] 89.8	Jan. 22, 1979	25		
Kosmos 1070	79–1A	Jan. 11, 1979	PL	A–2	5,900?	316	214	62.8	[1] 89.5	Jan. 20, 1979	9	Military photo	Recovered.
Pickaback	79–1F				200?	281	201	62.8	[2] 89.3	Jan. 27, 1979	16		
Kosmos 1071	79–2A	Jan. 13, 1979	PL	A–2	6,300?	360	190	62.8	[1] 89.7	Jan. 26, 1979	13	Military photo	Recovered.
Kosmos 1072	79–3A	Jan. 16, 1979	PL	C–1	680?	1,030	983	83	[1] 105			Navigation	3d Gen. "B".
Molniya 3–11	79–4A	Jan. 18, 1979	PL	A–2e	1,890?	40,806	474	62.8	[1] 736			Communications	
Tyazheliy Sputnik	79–4C				6,000?	407	183	62.8	[2] 90.4	Jan. 29, 1979	11	Launched Molniya	
Meteor 1–29	79–5A	Jan. 25, 1979	TT	A–1	3,475?	656	628	98	[1] 97.4			Meteorology	
Kosmos 1073	79–6A	Jan. 30, 1979	PL	A–2	6,300?	350	187	62.8	[1] 89.6	Feb. 12, 1979	13	Military photo	Recovered.
Kosmos 1074	79–8A	Jan. 31, 1979	TT	A–2	7,000?	258	203	51.6	[1] 88.8	Apr. 1, 1979	60	Man precursor	Soyuz T precursor.
						383	364	51.7	[2] 92.0				
Kosmos 1075	79–10A	Feb. 8, 1979	PL	C–1	900?	521	475	65.8	[1] 94.6			Radar calibration	
Kosmos 1076	79–11A	Feb. 12, 1979	PL	F–2	6,320?	678	647	82.5	[1] 97			Ocean resources	Comprehensive studies, largely in visual range.
Kosmos 1077	79–12A	Feb. 14, 1979	PL	A–1	3,800?	651	629	81.2	[1] 97.2			Elint ferret	
Ekran 3	79–15A	Feb. 21, 1979	TT	D–1e	2,700?	35,780	35,780	3.5	[1] 1,436			Communications	Statsionar T position.
Tyazheliy Sputnik	79–15C				18,000?	188	174	51.6	[2] 88.1	Feb. 22, 1979	1	Launched Ekran 3	
Kosmos 1078	79–16A	Feb. 22, 1979	PL	A–2	6,300?	306	160	72.9	[1] 89	Mar. 2, 1979	8	Military photo	Recovered.
Soyuz 32	79–18A	Feb. 25, 1979	TT	A–2	6,570?	256	193	51.6	[2] 88.9	June 13, 1979	108	Manned	Lyakhov, Ryumin, docked with Salyut 6, recovered unmanned.
						283	244	51.6	[1] 89.6				
Kosmos 1079	79–19A	Feb. 27, 1979	PL	A–2	6,700?	359	179	67.1	[1] 89.6	Mar. 11, 1979	12	Military photo	Recovered, solar panels.
Interkosmos 19	79–20A	Feb. 27, 1979	PL	C–1	550?	996	502	74	[1] 99.8			Geophysics	Ionosphere, radio propagation.
Meteor 2–4	79–21A	Mar. 1, 1979	PL	A–1	3,300?	908	857	81.2	[1] 102.3			Meteorology	
Progress 5	79–22A	Mar. 12, 1979	TT	A–2	7,020	269	191	51.6	[1] 88.8	Apr. 5, 1979	24	Man logistics	Docked with Salyut 6, burned up over the Pacific.
						325	243	51.6	[2] 90.6				
Kosmos 1080	79–23A	Mar. 14, 1979	PL	A–2	6,300?	230	180	72.9	[1] 89.2	Mar. 28, 1979	14	Military photo	Recovered.
Kosmos 1081–1088	79–24A–H	Mar. 15, 1979	PL	C–1	50?	1,526	1,455	74	[1] 115.4			Tactical communications octuple launch.	
Kosmos 1089	79–26A	Mar. 21, 1979	PL	C–1	680?	1,016	986	83	[1] 104.9			Navigation	3d Gen. "B".

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 1090	79–27A	Mar. 31, 1979	PL	A–2	5,700?	354	212	72.9	[1] 89.8	Apr. 13, 1979	1.3	Military photo	Recovered.
Kosmos 1091	79–28A	Apr. 7, 1979	PL	C–1	680?	1,024	985	83	[1] 105			Navigation	3d Gen. "B"
Soyuz 33	79–29A	Apr. 10, 1979	TT	A–2	6,570?	261	194	51.6	[2] 89.0	Apr. 12, 1979	2	Manned	Rukavishnikov, Ivanov recovered, failed to dock with Solyut 6.
						353	292	51.6	[2] 90.7				
Kosmos 1092	79–30A	Apr. 11, 1979	PL	C–1	680?	1,021	983	83	[1] 105			Navigation	4th Gen. "B", Civil.
Molniya 1–43	79–31A	Apr. 12, 1979	PL	A–2e	1,750?	40,590	656	62.9	[1] 735			Communications	
Tyazheliy Sputnik	79–31C				6,000?	592	196	62.9	[2] 92.4	May 5, 1979	23	Launched Moliniya	
Kosmos 1093	79–32A	Apr. 14, 1979	PL	A–1	3,800?	650	625	81.3	[1] 97.3			Elint ferret	
Kosmos 1094	79–33A	Apr. 18, 1979	TT	F–1m	4,150?	457	437	65	[1] 93.3	Nov. 7, 1979	203	Elint ocean surveillance	Ion propulsions.
Kosmos 1095	79–34A	Apr. 20, 1979	PL	A–2	6,300?	404	209	72.9	[1] 90.3	May 4, 1979	14	Military photo	Recovered.
						420	354	72.9	[2] 92.3				
Raduga 5	79–35A	Apr. 25, 1979	TT	D–1e	2,500?	36,000	36,000	0.4	[1] 1442			Communications	Statsionar 1 position.
Tyazheliy Sputnik	79–35C				1,800?	273	100	51.6	[2] 88.2	Apr. 25, 1979	0	Launched Raduga	
Kosmos 1096	79–36A	Apr. 25, 1979	TT	F–1m	4,150?	457	439	65	[1] 933	Nov. 24, 1979	213	Elint ocean surveillance	Ion propulsion.
Kosmos 1097	79–37A	Apr. 27, 1979	PL	A–2	6,700?	357	180	62.8	[1] 89.6	May 27, 1979	30	Military photo	Recovered. Solar panels.
Progress 6	79–39A	May 13, 1979	TT	A–2	7,020	268	193	51.6	[1] 88.8	June 9, 1979	28	Man logistics	Docked with Salyut 6, burned up over Pacific.
Kosmos 1098	79–40A	May 15, 1979	PL	A–2	6,300?	382	180	72.9	[1] 89.8	May 28, 1979	13	Military photo	Recovered, also Earth resources.
Kosmos 1099	79–41A	May 17, 1979	PL	A–2	5,900?	274	224	81.4	[1] 89.2	May 30, 1979	13	Military photo	Recovered, also Earth resources.
Pickaback	79–41C				200?	209	196	81.3	88.5	June 22, 1979	36		
Kosmos 1100	79–42A	May 22, 1979	TT	D–1	9,500?	230	199	51.6	[1] 88.6	May 23, 1979	0	Man procursor	Obscure mission, possibly reentry tests.
Kosmos 1101	79–42B				9,500?	230	199	51.6	[2] 88.6	May 23, 1979	0	Man precursor	
Kosmos 1102	79–43A	May 25, 1979	PL	A–2	5,900?	288	222	81.4	[1] 89.2	June 7, 1979	13	Military photo	Recovered, also Earth resources.
Pickaback	79–43D				200?	232	194	81.3	[2] 88.6	July 13, 1979	49		
Kosmos 1103	79–45A	May 31, 1979	PL	A–2	6,300?	396	264	6.28	[1] 90.8	June 14, 1979	14	Military photo	Recovered.
						417	325	6.28	[2] 92.0				
Kosmos 1104	79–46A	May 31, 1979	PL	C–1	680?	1,022	979	83	[1] 104.9			Navigation	3d Gen. "B".
Molniya 3–12	79–48A	June 5, 1979	PL	A–2e	1,890?	40,769	473	62.5	[1] 735			Communications	
Tyazheliy Sputnik	79–48C				6,000?	414	196	628	[2] 906	June 21, 1979	16	Launched Molniya	
Soyuz 34	79–49A	June 6, 1979	TT	A–2	6,570?	270	198	51.6	[1] 88.9	Aug. 19, 1979	74	Manned	Launched unmanned, docked Salyut 6, recovered with Lyakkov and Ryumin.
						364	289	51.6	[2] 91.0				
Bhaskara	79–51A	June 7, 1979	KY	C–1	444	557	512	50.7	[1] 95.2			Earth resources	Indian Bhaskar—Earth resources.
Kosmos 1105	79–52A	June 8, 1979	PL	A–2	5,900?	281	223	81.4	[1] 89.2	June 21, 1979	13	Military photo	Recovered, natural resources.
Pickaback	79–52D				200?	207	202	81.4	[2] 88.6	July 28, 1979	50		
Kosmos 1106	79–54A	June 12, 1979	PL	A–2	5,900	264	222	81.4	[1] 89.1	June 25, 1979	13	Military photo	Recovered, natural resources.
Pickaback	79–54D				200?	213	201	81.4	[2] 88.3	June 30, 1979	18		
Kosmos 1107	79–55A	June 15, 1979	PL	A–2	5,900?	328	209	72.9	[1] 89.5	June 29, 1979	14	Military photo	Recovered.
Pickaback	79–55D				200?	301	198	72.9	[2] 89.5	July 3, 1979	18		
Kosmos 1108	79–56A	June 22, 1979	PL	A–2	5,900?	272	224	81.3	[1] 89.1	July 5, 1979	13	Military photo	Recovered, natural resources.
Pickaback	79–56E				200?	212	198	81.3	[2] 88.6	July 21, 1979	29		
Kosmos 1109	79–58A	June 27, 1979	PL	A–2e	1,800?	40,130	626	62.8	[1] 720			Early warning	
Tyazheliy Sputnik	79–58C				6,000?	586	176	62.8	[2] 92.2	July 13, 1979	16	Launched Kosmos 1109	
Progress 7	79–59A	June 28, 1979	TT	A–2	7,020	270	193	51.6	[1] 88.8	July 20, 1979	22	Man logistics	Docked with Salyut 6, burned up over the Pacific.
						411	399	51.6	[2] 92.5				
Kosmos 1110	79–60A	June 28, 1979	PL	C–1	750?	833	792	74	[1] 101			Store-dump communications	
Kosmos 1111	79–61A	June 29, 1979	PL	A–2	6,300?	353	264	63	[1] 90.4	July 14, 1979	15	Military photo	Recovered.
						415	328	62.8	[2] 92.0				

Gorizont 2	79-62A	July 5, 1979	TT	D-1e	2,880?	36,550	36,550	0.8	[1] 1,477			Communications	Statsionar 4 position.
Tyazheliy Sputnik	79-62C				18,000?	162	147	51.6	[2] 87.5	July 7, 1979	2	Launched Gorizont	
Kosmos 1112	79-63A	July 6, 1979	KY	C-1	900?	552	345	50.7	[1] 93.4	Jan. 2, 1980	199	Radar calibration	Rocket exploded.
Kosmos 1113	79-64A	July 10, 1979	TT	A-2	6,300?	350	180	65	[1] 89.5	July 23, 1979	13	Military photo	Recovered.
Kosmos 1114	79-65A	July 11, 1979	PL	C-1	875?	558	507	74	[1] 95.2			Elint ferret	
Kosmos 1115	79-66A	July 13, 1979	PL	A-2	5,900?	263	222	81.4	[1] 89.1	July 26, 1979	13	Military Photo	Recovered, natural resources.
Pickaback	79-66C				200?	235	217	81.4	[2] 89.0	Aug. 20, 1979	38		
Kosmos 1116	79-67A	July 20, 1979	PL	A-1	3,800?	649	608	81.2	[1] 97.1			Elint ferret	
Kosmos 1117	79-68A	July 25, 1979	PL	A-2	6,300?	349	187	62.8	[2] 89.6	Aug. 7, 1979	13	Military photo	Recovered.
Kosmos 1118	79-69A	July 27, 1979	PL	A-2	5,700?	273	222	81.4	[1] 89.1	Aug. 9, 1979	13	Military photo	Recovered, natural resources.
Molniya 1-44	79-70A	July 31, 1979	PL	A-2e	1,750?	40,860	470	62.8	[1] 737			Communications	
Tyazheliy Sputnik	79-70C				6,000?	437	194	62.8	[2] 90.8	Aug. 14, 1979	14	Launched Molniya	
Kosmos 1119	79-71A	Aug. 3, 1979	PL	A-2	5,900?	267	222	81.3	[1] 89.1	Aug. 15, 1979	12	Military photo	Recovered, failed to separate.
Pickaback	79-71A				200?	267	222	81.3	89.1	Aug. 15, 1979	12		
Kosmos 1120	79-73A	Aug. 11, 1979	TT	A-2	6,300?	376	181	70.4	[1] 89.8	Aug. 24, 1979	13	Military photo	Recovered.
Kosmos 1121	79-74A	Aug. 14, 1979	PL	A-2	6,700?	375	180	67.2	[1] 89.7	Sept. 13, 1979	30	Military photo	Recovered. Solar panels.
Kosmos 1122	79-75A	Aug. 17, 1979	PL	A-2	5,700?	260	218	81.4	[1] 89.1	Aug. 30, 1979	13	Military photo	Recovered, natural resources.
Kosmos 1123	79-76A	Aug. 21, 1979	PL	A-2	5,900?	266	221	81.4	[1] 89.1	Sept. 3, 1979	13	Military photo	Recovered, natural resources.
Pickaback	79-76E				200?	218	202	81.4	[2] 88.7	Sept. 7, 1979	17		
Kosmos 1124	79-77A	Aug. 28, 1979	PL	A-2e	1,800?	40,070	620	62.8	[1] 724			Early warning	
Tyazheliy Sputnik	79-77C				6,000?	514	174	62.9	[2] 91.4	Sept. 11, 1979	14	Launched Kosmos 1124	
Kosmos 1125	79-78A	Aug. 28, 1979	PL	C-1	750?	834	795	74	[1] 100.9			Store-dump communications	
Kosmos 1126	79-79A	Aug. 31, 1979	PL	A-2	6,300?	421	208	72.9	[1] 90.5	Sept. 14, 1979	14	Military photo	Recovered.
						393	377	72.9	[2] 92.3				
Kosmos 1127	79-80A	Sept. 5, 1979	PL	A-2	6,300?	300	226	81.4	[1] 89.4	Sept. 18, 1979	13	Military photo	Recovered, natural resources.
						271	259	81.4	[2] 89.8				
Kosmos 1128	79-81A	Sept. 14, 1979	PL	A-2	6,300?	354	184	62.8	[1] 89.6	Sept. 27, 1979	13	Military photo	Recovered.
Kosmos 1129	79-83A	Sept. 25, 1979	PL	A-2	5,500?	406	226	62.8	[1] 90.5	Oct. 14, 1979	19	Biology	Recovered.
Pickaback	79-83E				200?	391	209	62.8	[2] 90.5	Mar. 16, 1980	173		
Kosmos 1130-1137	79-84A-H	Sept. 25, 1979	PL	C-1	50?	1,515	1,446	74	[1] 115			Tactical communications octuple launch.	
Vertikal 8		Sept. 26, 1979	KY		3,000?	505up				Sept. 26, 1979	0	Geophysical probe	Interkosmos.
Kosmos 1138	79-85A	Sept. 28, 1979	PL	A-2	6,300?	398	210	72.9	[1] 90.2	Oct. 12, 1979	14	Military photo	Recovered.
						411	364	72.9	[2] 92.3				
Ekran 4	79-87A	Oct. 3, 1979	TT		2,700?	35,557	35,557	0.45	[1] 1,424			Communications	Statsionar T position.
Tyazheliy Sputnik	79-87C				18,000?	193	177	51.6	[2] 88.1	Oct. 4, 1979	1	Launched Ekran 4	
Kosmos 1139	79-88A	Oct. 5, 1979	PL	A-2	5,900?	357	212	72.9	[1] 89.9	Oct. 18, 1979	13	Military photo	Recovered, mapping geodesy resources.
Pickaback	79-88C				200?	333	191	72.9	[3] 898				
Kosmos 1140	79-89A	Oct. 11, 1979	PL	C-1	750?	818	781	74	[1] 101			Store-dump communications	
Kosmos 1141	79-90A	Oct. 16, 1979	PL	C-1	680?	1,014	976	82.9	[1] 104.7			Navigation	3d Gen. "B".
Molniya 1-45	79-91A	Oct. 20, 1979	PL	A-2e	1,750?	40,640	640	62.8	[1] 736			Communications	
Tyazheliy Sputnik	79-91C				6,000?	604	201	62.9	[2] 92.6	Nov. 10, 1979	21	Launched Molniya	
Kosmos 1142	79-92A	Oct. 22, 1979	PL	A-2	6,300?	403	203	72.9	[1] 90.3	Nov. 4, 1979	13	Military photo	Recovered.
						418	353	72.9	[2] 92.3				
Kosmos 1143	79-93A	Oct. 26, 1979	PL	A-1	3,800?	665	625	81.2	[1] 97.4			Elint ferret	
Meteor 2-5	79-95A	Oct. 31, 1979	PL	A-1	3,300?	904	877	81.2	[1] 102.6			Meteorology	

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Interkosmos 20	79-96A	Nov. 1, 1979	PL	C-1	880?	523	467	74	[1] 94.4			Ocean resources	Also data relay from buoys.
Kosmos 1144	79-97A	Nov. 2, 1979	PL	A-2	6,700?	378	179	67.2	[1] 89.8	Dec. 4, 1979	32	Military photo	Recovered. Solar panels.
Kosmos 1145	79-99A	Nov. 27, 1979	PL	A-1	3,800?	652	629	81.2	[1] 97.3			Elint ferret	
Kosmos 1146	79-100A	Dec. 5, 1979	PL	C-1	900?	497	441	65.9	[1] 93.9			Radar calibration	
Kosmos 1147	79-102A	Dec. 12, 1979	PL	A-2	6,300?	407	207	72.9	[1] 90.3	Dec. 26, 1979	14	Military photo	Recovered.
						414	354	72.9	[2] 92.3				
Soyuz T-1	79-103A	Dec. 16, 1979	TT	A-2	7,000?	232	201	51.6	[1] 88.6	Mar. 25, 1980	100	Unmanned	Docked with Salyut 6, recovered.
						382	370	51.6	[2] 91.9				
Gorizont 3	79-105A	Dec. 28, 1979	TT	D-1e	2,880?	36,300	36,300	0.8	[1] 1463			Communications	Statsionar 5 position.
Tyazheliy Sputnik	79-105C				18,000?	157	142	51.6	[2] 84.7	Dec. 30, 1979	2	Launched Gorizont	
Kosmos 1148	79-106A	Dec. 28, 1979	PL	A-2	6,300?	367	180	67.1	[1] 89.7	Jan. 10, 1980	13	Military photo	Recovered.
Kosmos 1149	80-1A	Jan. 9, 1980	PL	A-2	6,300?	414	208	72.9	[1] 90.4	Dec. 23, 1980	14	Military photo	Recovered.
						420	353	72.9	[2] 92.3				
Molniya 1-46	80-2A	Jan. 11, 1980	PL	A-2e	1,750?	40,830	478	628	[1] 737			Communications	
Tyazheliy Sputnik	80-2C				6,000?	491	215	62.9	[2] 91.6	Dec. 24, 1980	13	Launched Molniya	
Kosmos 1150	80-3A	Jan. 14, 1980	PL	C-1	680?	1,028	998	83	[1] 105			Navigation	3d Gen. "B".
Kosmos 1151	80-5A	Jan 23, 1980	PL	F-2	6,320?	678	650	82.5	[1] 97.8			Ocean resources	Improved over Kosmos 1076 to cover wider spectrum.
Kosmos 1152	80-6A	Jan. 24, 1980	PL	A-2	6,700?	370	181	67.1	[1] 89.7	Feb. 6, 1980	13	Military photo	Recovered. Solar panels.
Kosmos 1153	80-7A	Jan. 25, 1980	PL	C-1	680?	1,031	983	83	[1] 105			Navigation	3d Gen. "B".
Kosmos 1154	80-8A	Jan. 30, 1980	PL	A-1	3,800?	671	634	81.3	[1] 97.3			Elint ferret	
Kosmos 1155	80-9A	Feb. 7, 1980	PL	A-2	6,300?	422	206	72.9	[1] 90.4	Feb. 21, 1980	14	Military photo	Recovered.
						416	357	72.9	[2] 92.3				
Kosmos 1156-1163	80-12A-H	Feb. 11, 1980	PL	C-1	50?	1,528	1,450	74	[1] 115.4			Tactical communications octuple launch.	
Kosmos 1164	80-13A	Feb. 12, 1980	PL	A-2e	1,890?	640	220	62.8	[1] 92.9	Jan. 14, 1981	337	Communications	Probably a failed Molniya.
Tyazheliy Sputnik	80-13C				6,000?	611	235	62.9	[2] 93.0	Apr. 3, 1980	51	Launched Kosmos 1164	
Raduga 6	80-16A	Feb. 20, 1980	TT	D-1e	2,500?	36,610	36,610	0.4	[1] 1,478			Communications	Statsionar 2 position.
Tyazheliy Sputnik	80-16C				18,000?	191	178	51.6	[2] 88.1	Feb. 22, 1980	2	Launched Raduga	
Kosmos 1165	80-17A	Feb. 21, 1980	PL	A-2	6,300?	379	182	72.9	[1] 89.8	Mar. 5, 1980	13	Military photo	Recovered.
Kosmos 1166	80-20A	Mar. 4, 1980	PL	A-2	6,300?	406	208	72.9	[1] 90.3	Mar. 18, 1980	14	Military photo	Recovered.
						416	356	72.9	[2] 92.3				
Kosmos 1167	80-21A	Mar. 14, 1980	TT	F-1m	4,150?	457	433	65	[1] 93.3			Elint ocean surveillance	Ion propulsion.
Kosmos 1168	80-22A	Mar. 17, 1980	PL	C-1	680?	1,028	981	82.9	[1] 104.9			Navigation	3d Gen. "B".
Kosmos 1169	80-23A	Mar. 27, 1980	PL	C-1	900?	521	478	65.8	[1] 94.5			Radar calibration	
Progress 8	80-24A	Mar. 27, 1980	TT	A-2	7,020	266	192	51.6	[1] 88.8	Apr. 26, 1980	30	Man logistics	Docked with Salyut 6, burned up over the Pacific.
						242	230	51.6	[2] 89.2				
Kosmos 1170	80-25A	Apr. 1, 1980	TT	A-2	6,300	386	181	70.4	[1] 89.9	Apr. 12, 1980	11	Military photo	Recovered.
Kosmos 1171	80-26A	Apr. 3, 1980	PL	C-1	750?	1,017	976	65.8	[1] 105			Target for ASAT	
Soyuz 35	80-27A	Apr. 9, 1980	TT	A-2	6,570?	247	197	51.6	[2] 88.0	June 3, 1980	55	Manned	Popov, Ryumin, docked Salyut 6, recovered with Kubasov, Farkas.
						315	276	51.6	[1] 90.3				
Kosmos 1172	80-28A	Apr. 12, 1980	PL	A-2e	1,800?	40,160	637	62.8	[1] 726			Early warning	

Tyazheliy Sputnik	80–28C				6,000?	587	213	62.8	[2] 92.6	May 8, 1980	26	Launched Kosmos 1172	
Kosmos 1173	80–29A	Apr. 17, 1980	TT	A–2	5,900?	379	180	70.3	[1] 89.9	Apr. 28, 1980	11	Military photo	Recovered.
Pickaback?	80–29C				200?	328	154	70.3	[2] 89.3	Apr. 30, 1980	13		
Kosmos 1174	80–30A	Apr. 18, 1980	TT	F–1m	3,320	340	124	65.2	[2] 89.1			ASAT	Passed near Kosmos 1171, then exploded a day later.
						1,035	387	65.8	[1] 98.6				
						1,660	381	66.1	[2] 105.5				
Kosmos 1175	80–31A	Apr. 18, 1980	PL	A–2e	1,890?	485	317	62.5	[1] 92.3	May 28, 1980	40	Communications	Probably a failed Molniya.
Tyazheliy Sputnik	80–31B				6,000?	451	253	62.8	[2] 91.6	May 28, 1980	40	Launched Kosmos 1175	
Progress 9	80–33A	Apr. 27, 1980	TT	A–2	7,020	275	192	51.6	[1] 88.9	May 22, 1980	25	Man logistics	Docked with Salyut 6, burned up over the Pacific.
						350	244	51.7	[2] 90.4				
Kosmos 1176	80–34A	Apr. 29 1980	TT	F–1m	4,540?	265	260	65	[1] 89.6			Radar ocean surveillance	Possibly nuclear powered moved to higher orbit, Sept. 10, 1980.
						965	870	64.8	[2] 103.4				
Kosmos 1177	80–35A	Apr. 29, 1980	PL	A–2	6,700?	365	181	67.2	[1] 89.7	June 12, 1980	44	Military photo	Recovered. Solar panels.
Kosmos 1178	80–36A	May 7, 1980	PL	A–2	6,300?	417	207	72.9	[1] 90.4	May 22, 1980	15	Military photo	Recovered.
						415	358	72.8	[2] 92.3				
Kosmos 1179	80–37A	May 14, 1980	PL	C–1	650?	1,570	310	83	[1] 103.5			Radar calibration	
Kosmos 1180	80–38A	May 15, 1980	PL	A–2	5,900?	296	240	62.8	[1] 89.8	May 26, 1980	12	Military photo	Recovered, mapping geodesy, resources.
Pickaback	80–38E				200?	399	264	62.8	[2] 91.1	May 31, 1980	16		
Kosmos 1181	80–39A	May 20, 1980	PL	C–1	680?	1,020	992	83	[1] 105			Navigation	3rd Gen. "B".
Kosmos 1182	80–40A	May 23, 1980	PL	F–2	7,420?	278	221	82.3	[1] 89.2	June 5, 1980	13	Military photo	Recovered, Earth resources.
Soyuz 36	80–41A	May 26, 1980	TT	A–2	6,570?	265	171	51.6	[2] 89.0	July 31, 1980	66	Manned	Kubasov, Farkas, docked with Salyut 6, recovered with Gorbatko, Pham Tuam.
						319	263	51.6	[1] 90				
Kosmos 1183	80–42A	May 28, 1980	PL	A–2	6,300?	414	208	72.9	[1] 90.4	June 11, 1980	14	Military photo	Recovered.
						416	358	72.9	[2] 92.3				
Kosmos 1184	80–44A	June 4, 1980	PL	A–1	3,800?	662	621	81.2	[1] 97.4			Elint ferret	
Soyuz T–2	80–45A	June 5, 1980	TT	A–2	7,000?	231	195	51.6	[2] 88.7	June 9, 1980	4	Manned	Malyshev, Aksenov, recovered, docked with Salyut 6.
						316	267	51.6	[1] 90.2				
Kosmos 1185	80–46A	June 6, 1980	PL	F–2	7,420?	308	226	82.3	[1] 89.5	June 20, 1980	14	Military photo	Recovered, also Earth resources.
						275	261	82.3	[2] 89.9				
Kosmos 1186	80–47A	June 6, 1980	PL	C–1	900	519	473	74	[1] 94.5			Radar calibration	
Kosmos 1187	80–48A	June 12, 1980	PL	A–2	6,300?	332	210	72.9	[1] 89.6	June 26, 1980	14	Military photo	Recovered.
						291	227	72.9	[2] 89.7				
Gorizont 4	80–49A	June 14, 1980	TT	D–1e	2,880?	36,513	36,513	0.8	[1] 1,473			Communications	Statsionar 4 position.
Tyazheliy Sputnik	80–49C				18,000?	184	172	51.6	[2] 88.0	June 19, 1980	0	Launched Gorizont	
Kosmos 1188	80–50A	July 14, 1980	PL	A–2e	1,800?	40,165	628	62.8	[1] 726			Early warning	
Tyazheliy Sputnik	80–50C				6,000?	581	221	62.8	[2] 92.6	July 17, 1980	33	Launched Kosmos 1188	
Meteor 1–30	80–51A	June 18, 1980	TT	A–1	3,475	678	589	98	[1] 97.3			Meteorology	
Molniya 1–47	80–53A	June 21, 1980	PL	A–2e	1,750?	40,707	658	62.5	[1] 738			Communications	
Tyazheliy Sputnik	80–53C				6,000?	597	199	62.8	[2] 92.5	July 25, 1980	34	Launched Molniya	
Kosmos 1189	80–54A	June 26, 1980	PL	A–2	6,300?	330	209	72.9	[1] 89.5	July 10, 1980	14	Military photo	Recovered.
Progress 10	80–55A	June 29, 1980	TT	A–2	7,020?	281	191	51.6	[1] 88.9	July 19, 1980	20	Man logistics	Docked with Salyut 6.
Kosmos 1190	80–56A	July 1, 1980	PL	C–1	750?	829	792	74	[1] 100.8			Store-dump communications	
Kosmos 1191	80–57A	July 2, 1980	PL	A–2e	1,800?	40,165	646	628	[1] 726			Early warning	
Tyazheliy Sputnik	80–57				6,000?	625	198	62.8	[2] 92.8	July 31, 1980	29	Dumped Kosmos 1191	
Kosmos 1192–1199	80–58A–H	July 9, 1980	PL	C–1	50?	1,522	1,451	74	[1] 115.3			Tactical communications octuple launch.	

Payload name	Designator	Launch date	Site	Launch vehicle	Weight	Apogee	Perigee	Inclination	Period (in minutes)	Decay date	Days life	Mission	Remarks
Kosmos 1200	80–59A	July 9, 1980	PL	A–2	6,300?	332	209	72.9	^{1} 89.5	July 23, 1980	14	Military photo	Recovered.
						291	227	72.9	^{2} 89.7				
Ekran 5	80–60A	July 14, 1980	TT	D–1e	2,700?	35,474	35,474	0.36	^{1} 1,420			Communications	Statsionar T position.
Tyazheliy Sputnik	80–60C				18,000?	165	138	51.6	^{2} 87.5	July 15, 1980	0	Launched Ekran	
Kosmos 1201	80–61A	July 15, 1980	PL	F–2	7,220?	274	220	82.3	^{1} 89.1	July 28, 1980	13	Military photo	Recovered, also Earth resources.
Pickaback	80–61D				200?					Aug. 2, 1980			
Molniya 3–13	80–63A	July 18, 1980	PL	A–2e	1,890?	40,815	467	62.8	^{1} 736			Communications	
Tyazheliy Sputnik	80–63C				6,000?	463	208	62.8	^{2} 91.2	Aug. 4, 1980	17	Launched Molniya	
Soyuz 37	80–64A	July 23, 1980	TT	A–2	6,570?	272	190	51.6	^{2} 89.1	Oct. 11, 1980	80	Manned	Gorbatko, Pham Tuan docked with Salyut 6.
						294	258	51.6	^{2} 90.0				
Kosmos 1202	80–65A	July 24, 1980	PL	A–2	6,300?	333	209	72.9	^{1} 89.6	Aug. 7, 1980	14	Military photo	Recovered.
Kosmos 1203	80–66A	July 31, 1980	PL	F–2	7,420?	303	227	82.3	^{1} 89.5	Aug. 14, 1980	14	Military photo	Recovered, also Earth resources.
						274	261	82.3	^{2} 89.9				
Kosmos 1204	80–67A	July 31, 1980	KY	C–1	900?	546	346	50.7	^{1} 93.3	Feb. 23, 1981	207	Radar calibration	
Kosmos 1205	80–68A	Aug. 12, 1980	PL	A–2	6,300?	332	208	72.8	^{1} 89.6	Aug. 26, 1980	14	Military photo	Recovered.
						288	229	72.8	^{2} 89.7				
Kosmos 1206	80–69A	Aug. 15, 1980	PL	A–1	3,800?	659	630	81.2	^{1} 97.4			Elint ferret	
Kosmos 1207	80–70A	Aug. 22, 1980	PL	F–2	7,220?	282	218	82.3	^{1} 89.2	Sept. 4, 1980	13	Military photo	Recovered, Earth resources.
Pickaback	80–70C				200?	213	209	82.3	^{2} 88.8	Sept. 8, 1980	17		
Kosmos 1208	80–71A	Aug. 26, 1980	PL	A–2	6,700?	362	181	67.1	^{1} 89.6	Sept. 24, 1980	29	Military photo	Recovered. Solar panels.
Kosmos 1209	80–72A	Sept. 3, 1980	PL	F–2	7,420?	306	222	82.3	^{1} 89.4	Sept. 17, 1980	14	Military photo	Recovered, Earth resources.
						274	261	82.3	^{2} 89.9				
Meteor 2–6	80–73A	Sept. 9, 1980	PL	A–1	3,300?	906	868	81.2	102.4			Meteorology	
Soyuz 38	80–75A	Sept. 18, 1980	TT	A–2	6,570?	257	195	51.6	89.0	Sept. 26, 1980	8	Manned	Romanenko, Tamayo Mendez docked with Salyut 6, recovered.
						313	263	51.6	90.2				
Kosmos 1210	80–76A	Sept. 19, 1980	PL	F–2	7,420?	268	195	82.3	^{1} 88.8	Oct. 3, 1980	14	Military photo	Recovered.
						320	187	82.3	^{2} 89.6				
Kosmos 1211	80–77A	Sept. 23, 1980	PL	F–2	7,220?	261	215	82.4	89.1	Oct. 4, 1980	11	Military photo	Recovered. Mapping, geodesy, resources.
Pickaback					200?								
Kosmos 1212	80–78A	Sept. 26, 1980	PL	F–2	7,220?	275	216	82.3	89.1	Oct. 9, 1980	14	Military photo	Recovered, Earth resources.
Pickaback	80–78D				200?	200	183	82.3	88.3	Oct. 11, 1980	16		
Progress II	80–79A	Sept. 28, 1980	TT	A–2	7,020?	270	193	51.6	88.8	Dec. 11, 1980	74	Man logistics	Docked with Salyut 6, burned up over the Pacific.
						340	260	51.6	90.5				
Kosmos 1213	80–80A	Oct. 3, 1980	PL	A–2	6,300?	343	207	72.8	89.6	Oct. 17, 1980	14	Military photo	Recovered.
						336	235	72.9	90.2				
Raduga 7	80–81A	Oct. 5, 1980	TT	D–1e	2,500?	36,000	36,000	0.4	^{1} 1,444			Communications	Statsionar 3 position.
Tyazheliy Sputnik	80–81C				18,000?	200	135	51.6	^{2} 87.8	Oct. 6, 1980	1	Launched Raduga 7	
Kosmos 1214	80–82A	Oct. 10, 1980	PL	A–2	5,700?	368	181	67.2	89.7	Oct. 23, 1980	13	Military photo	Recovered.
Kosmos 1215	80–83A	Oct. 14, 1980	PL	C–1	900?	553	449	74	^{1} 95.1			Radar calibration	
Kosmos 1216	80–84A	Oct. 16, 1980	PL	A–2	6,300?	404	209	72.9	^{1} 90.3	Oct. 30, 1980	14	Military photo	Recovered.
						404	367	72.9	^{2} 92.3				
Kosmos 1217	80–85A	Oct. 24, 1980	PL	A–2e	1,800?	40,165	642	62.8	^{1} 726			Early warning	
Tyazheliy Sputnik	80–85C				6,000?	594	211	62.8	^{2} 92.6	Nov. 7, 1980	14	Launched Kosmos 1217	
Kosmos 1218	80–86A	Oct. 30, 1980	TT	A–2	6,700?	374	178	64.9	^{1} 89.7	Dec. 12, 1980	43	Military photo	Recovered, solar panels.
Kosmos 1219	80–88A	Oct. 31, 1980	PL	A–2	6,300?	353	205	72.9	^{1} 89.7	Nov. 13, 1980	13	Military photo	Recovered.
Kosmos 1220	80–89A	Nov. 4, 1980	TT	F–1m	4,150?	454	432	65	^{1} 93.3			Elint ocean surveillance	Ion propulsion.

Kosmos 1221	80–90A	Nov. 12, 1980	PL	A–2	6,300?	424	207	72.9	[1] 90.5	Nov. 26, 1980	14	Military photo	Recovered
						417	356	72.9	[2] 92.3				
Molniya 1–48	80–92A	Nov. 16, 1980	PL	A–2e	1,750?	40,651	640	62.8	[1] 736			Communications	
Tyazheliy Sputnik	80–92C				6,000?	601	212	62.8	[2] 92.7	Dec. 12, 1980	26	Launched Molniya	
Kosmos 1222	80–93A	Nov. 21, 1980	PL	A–1	3,800?	659	624	81.2	[1] 97.4			Elint Ferret	
Soyuz T–3	80–94A	Nov. 27, 1980	TT	A–2	7,000?	260	255	51.6	[2] 89.6	Dec. 10, 1980	13	Manned	Kizim, Makarov, Strekalov, docked with Salyut 6, recovered.
Kosmos 1223	80–95A	Nov. 27, 1980	PL	A–2e	1,800?	40,165	614	62.8	[1] 726			Early warning	
Tyazheliy Sputnik	80–95C				6,000?	583	213	62.8	[2] 92.5	Dec. 21, 1980	24	Launched Kosmos 1223	
Kosmos 1224	80–96A	Dec. 1, 1980	PL	A–2	6,300?	403	209	72.9	[1] 90.3	Dec. 15, 1980	14	Military photo	Recovered.
						408	351	72.9	[2] 92.2				
Kosmos 1225	80–97A	Dec. 5, 1980	PL	C–1	680?	1,041	967	82.9	[1] 105			Navigation	3d Gen. "B".
Kosmos 1226	80–99A	Dec. 11, 1980	PL	C–1	680?	1,025	982	83	[1] 105			Navigation	4th Gen. "B", civil.
Kosmos 1227	80–101A	Dec. 16, 1980	PL	A–2	6,300?	325	209	72.9	[1] 89.5	Dec. 28, 1980	12	Military photo	Recovered.
Kosmos 1228–1235	80–102A–H	Dec. 24, 1980	PL	C–1	50?	1,491	1,415	74	114.6			Tactical communications octuple launch.	
Prognoz 8	80–103A	Dec. 25, 1980		A–2e	910?	199,000	550	65	5,723			Geophysics	Solar wind and magnetosphere.
Tyazheliy Sputnik	80–103B				6,000?	499	234	65.1	91.9			Launched Prognoz 8	
Ekran 6	80–104A	Dec. 26, 1980	TT	D–1e	2,700?	35,554	35,554	0.4	1,424			Communications	Statsionar T position.
Tyazheliy Sputnik	80–104C				18,000?	156	141	51.6	87.4	Dec. 27, 1980	1	Launched Ekran 6	
Kosmos 1236	80–105A	Dec. 26, 1980	PL	A–2	6,700?	388	180	67.1	89.8			Military photo	Recovered. Solar panels.

ERRATA SHEET

Cover, title page, page v, paragraph 2, lines 1 and 2, and page vii, paragraph 3, lines 1 and 2; should read: "Supporting facilities and launch vehicles".